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ABSTRACT

In 1992, RAND received a grant from the National Science Foundation to study the technical quality of performance assessments in science and to evaluate their feasibility for use in large-scale testing programs. The specific goals of the project were to assess the reliability and validity of hands-on science testing and to investigate the cost and practicality of these types of measures for large-scale assessment. The purpose of this monograph is to make the science tasks and scoring guides developed as part of the project available to other researchers and educational practitioners. This collection of measures is designed to provide researchers with a basic set of tasks they can build upon when studying student performance in science and investigating alternative approaches to science assessment. For this reason, information is reported about the conditions under which the tasks were administered and the reliability of the scoring guides (inter-reader correlations). The tasks should also be useful to practitioners in their discussions about measuring student performance in science, the types of activities that may be used in future state and national assessment systems, and the changes that need to take place in staff development. The document contains a complete description of each task used in the study, including the shell (or testing blueprint) from which the task was developed and copies or photos of the task booklet, the materials or apparatus that accompanied the task, the scoring guide, and the form used to record scores. The task topics studied include incline, force, friction, pendulum, lever, classification of animals, classification of materials, acids and bases--vinegar, acids and bases--alien, radiation, rate of cooling, heat, temperature, rosion and pollution. Contains nine tables and nine references. (Author/MVL)

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RAND

Performance Assessments in Science

Hands-On Tasks and Scoring Guides

Edited by Brian M. Stecher, Stephen P. Klein

Institute on Education and Training

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Preface

In 1992, RAND received a grant from the National Science Foundation to study the technical quality of performance assessments in science and to evaluate their feasibility for use in large-scale testing programs. The specific goals of the project were to assess the reliability and validity of hands-on science testing and to investigate the cost and practicality of these types of measures for large-scale assessment. RAND collaborated with researchers from the University of California, Santa Barbara; Stanford University; the Far West Laboratory; and the California State Department of Education to develop and administer several science exercises to students in elementary, middle, and high schools in 1993 and 1994. Findings regarding the development, quality, and feasibility of hands-on science assessments have been reported in a number of papers and journal articles (see References).

The purpose of this monograph is to make the science tasks and scoring guides developed as part of the project available to other researchers and educational practitioners. This collection of measures should provide researchers with a basic set of tasks they can build upon when studying student performance in science and investigating alternative approaches to science assessment. For this reason, we report information about the conditions under which the tasks were administered and the reliability of the scoring guides (inter-reader correlations). The tasks should also be useful to practitioners in their discussions about measuring student performance in science, the types of activities that may be used in future state and national assessment systems, and the changes that need to take place in staff development.

This document contains a complete description of each task used in the study, including the shell (or testing blueprint) from which the task was developed and copies or photos of the task booklet, the materials or apparatus that accompanied the task, the scoring guide, and the form those who scored the tests used to record scores. We anticipate that this information will allow the interested reader to reproduce all the tasks used in the project.

Contents

Figures

Tables

Acknowledgments

The following individuals contributed to the development of the tasks, materials, and scoring guides presented here. In effect, they are the authors of this report. From RAND: Stephen P. Klein, who was the principal investigator; Brian M. Stecher; Bryan Hallmark; Hilary Saner; Abby Robyn; Eric Hamilton; and Allen Ruby. From the University of California, Santa Barbara: Richard Shavelson, director; Guillermo Solano-Flores; Gail Baxter; and Jasna Jovanovich. From Stanford University: Edward H. Haertel, director; Laura Hamilton; Carrie Jones; E. Michael Nussbaum; and Jerome M. Shaw. From the Far West Laboratory: Steven Schneider, director; Justine Reese; and Mary Pat O'Connell. From the California Learning Assessment System (CLAS): Kathleen Comfort, director; Paul Michaelson; Michael Trulson; Jody McCarthy; and members of the CLAS Science Assessment Advisory Committee and Science Assessment Development Teams.

In addition, we want to thank Robert Bell and Daniel McCaffrey, from RAND, for their contribution to the design of the scoring system, and Jim Chiesa, Gail Yeaple, and Judy Wood for help in producing this complex document.

1. Introduction

Recent reforms of science and mathematics curricula emphasize problem-solving and conceptual understanding rather than knowledge of facts and formulas. Many educators argue for a corresponding change in testing. Specifically, reformers believe that the reliance on multiple-choice tests, the traditional measures of achievement, should be replaced by use of alternative assessment methods, including hands-on science exercises and other performance-oriented assessments. These measurement strategies are intended to assess conceptual understanding and the ability to apply knowledge and skills to solve problems. Reformers hope that such tests will encourage the teaching of mathematical and scientific problem-solving and provide the tools needed to assess student and school progress toward achieving the goals of the new curricula. However, little is known about the reliability and validity of hands-on assessments for these purposes or how they compare with multiple-choice tests, whose strengths and weaknesses have been well documented over the years.

RAND collaborated with several organizations to examine these questions about hands-on assessments. The project explored the cost, technical quality, feasibility, and acceptability of alternative assessments from the domain of science. Our initial results suggest that hands-on tasks can be developed efficiently and scored reliably (Haertel et al., 1995; Solano-Flores and Shavelson, 1994; Saner et al., 1994b). Furthermore, students and teachers enjoy this type of assessment (Hamilton, 1994a). However, the costs of equipment and scoring are many times higher than multiple choice tests and may be prohibitive for some jurisdictions (Stecher, 1995). We are just beginning to explore the interpretation of student scores with respect to broader content domains. Early investigations reveal that student performance on a task can be affected by subtle nuances in presentation and format (Hamilton, 1994b). Additional findings regarding the comparability of performance within and between shells (testing blueprints) and the interpretation of student scores on multiple tasks will be reported in the near future.

A significant portion of our energy was devoted to developing new hands-on activities to measure science ability and administering them to students under controlled conditions. We began with testing blueprints, called "shells," from which we derived specific tasks. All of the tasks required some manipulation of equipment or materials as part of the solution. Students received task booklets and a kit of materials. The booklets explained the use of the materials and presented a problem situation for the students. Each problem contained a series of specific questions that the students answered by writing directly in the task booklets. Scoring guides were developed at the same time as the tasks, and experienced science teachers (whom we will call "readers") were trained to read student responses and assign points. These scores formed the basis for the analyses of task quality, which will be reported elsewhere.

Here, we document the tasks designed by the project and all the materials used in the experiments. These materials include the task design shells, the task booklets, the equipment, the scoring guides, and the reader recording forms.

Design Shells and Tasks

One of the challenges that must be addressed by developers of performance tasks (particularly tasks that will be used in large-scale testing programs) is the need to produce multiple versions of an activity that are as similar as possible. Our approach to doing this was to generate multiple tasks from a common blueprint or "shell." The shells described critical features of each task, such as its structure, the types of variables involved, and the cognitive and procedural demands placed on students. One of the goals of the project was to compare student performance on similar tasks (derived from the same shell) and dissimilar tasks (derived from different shells) to determine the degree to which this approach produced exercises that had the characteristics of parallel tests. Most of the tasks used in this project were produced in pairs from such detailed task descriptions.

Table 1 lists the shells and associated tasks described in this report. In most cases, the same team developed the shell and both tasks. However the Acids and Bases shell was produced jointly by the University of California, Santa Barbara (UCSB) and Stanford University/Far West Laboratory. Three versions of the Acid and Bases shell were developed by varying the level of inquiry and structure. The "text" version did not have a hands-on component, the "recipe" version led students through hands-on performance in small steps, and the "discovery" version asked students to design and conduct an experiment with few procedural cues. Working independently, the UCSB and Stanford/Far West teams each developed tasks corresponding to the text, recipe, and discovery versions of the Acids and Bases shell. In future analyses, we will examine the effects of taking a task at one level of inquiry (e.g., recipe) on performance on a subsequent task at another level of inquiry (e.g., discovery). The project also administered tasks that were developed by the California State Department of Education through its California Learning Assessment System (CLAS) program.

Table 1

Shells and Tasks

Shell	Tasks	Developer	Target Grade Level
Force and Motion	Incline and friction	UCSB	5
Inference	Pendulum and lever	RAND	6
Classification	Animals and materials	RAND	6
Acids and Bases (text version)	Alien and vinegar	UCSB and Stanford/ Far West	8
Acids and Bases (recipe version)	Alien and vinegar	UCSB and Stanford/ Far West	8
Acids and Bases (discovery version)	Alien and vinegar	UCSB and Stanford/ Far West	8
Heat and Energy	Radiation and rate of cooling	Stanford and Far West	9
None	Rocks, roads and critters	CLAS	5
None	Animals, hot rocks, and erosion	CLAS	10

The task development teams agreed on the essential elements of a shell and on a common view of the process of learning and doing science, one that was consistent with the California State Framework for Science. This common perspective is apparent in the Force and Motion shell for the incline and friction tasks. This shell highlights four elements of scientific experimentation—planning and design, performance, analysis and interpretation, and application. (This shell also permits variations in the level of inference demanded of students.) Although the Inference shell for lever and pendulum is more terse, it places very similar demands on students in terms of design, performance, analysis, and application. The same is true for the Heat and Energy shell, which generated the radiation and rate of cooling tasks. These underlying similarities may be less obvious because the shells differ in presentation; the formats for the shells include prose descriptions, tabular representations, and mapping sentences. In the future, we plan to produce a report that discusses the different approaches to shell development and presentation.

In designing shells and constructing tasks, we did not attempt to sample from the domain of science in any systematic manner. That was not the focus of this project. Teams chose the science content areas and objectives on the basis of interest, experience, and convenience.

Brief Descriptions

The complete shells and tasks will be found in the following sections. Here is a brief overview to illustrate the range and scope of the activities.

Force and Motion

In the incline task, students explore the relationship between the force required to pull a truck up a ramp and the steepness of the ramp. In the friction task, they examine the relationship between the force needed to pull a block across a surface and the texture of the surface. Students have 50 minutes to complete each task.

Inference

In the pendulum task, students explore the relationship between the length of a pendulum, the weight of the suspended object, and the periodicity of the pendulum. In the lever task, students examine the relationship between the length of a lever, the position of the fulcrum, and the lifting ability of the lever. Students are given 25 minutes to complete each task.

Classification

Students learn about two-way cross-classifications in which each dimension has two levels (e.g., gender: male and female; posture: sitting and standing). In the animals task, they are given a set of animals, and they must create a two-way classification system so that each animal fits in only one cell and each cell has at least one animal in it. The materials task is the same, except the objects to be classified are natural materials. Each task requires 25 minutes.

Acids and Bases

There are three versions of the Acids and Bases shell. The discovery version provides basic information about acids and bases, introduces a problem and asks students to design and carry out their own experiment to solve it. The recipe version provides the same general instructions and problem situation, but it provides specific procedures the students follow to solve the problem. The text version is set up in the same manner as the recipe, except students only read about the results of the experiment—they do not conduct it.

In the alien task, students use pH paper to determine whether the blood of an ill alien is too acidic or too basic and to decide which of three solutions is the best antidote for the alien's disease. In the vinegar task, students use universal indicator solution to determine which of two acids is stronger and how much of a base is needed to neutralize one of the acids. They apply this knowledge to a question involving vinegar. Students have 50 minutes to complete each task.

Heat and Energy

This activity lasts four class periods (50 minutes each), including a period in which each student works in a group to become familiar with the equipment, a period for designing an experiment individually, a period for collecting data as a group activity, and a period for individual analysis of a common set of data. The tasks are administered over four consecutive days. In the radiation task, students explore the relationship between color and heat absorption. In the rate of cooling task, students examine the insulating properties of different fabrics.

CLAS Fifth Grade

In the rocks task, students use tools to investigate the properties of three rocks to determine which would be the best material for building outdoor tables and benches. In the roads task, students compare the force required to pull a truck across smooth and gravel roads. In the critters task, students sort and classify plastic organisms into categories and present rationales for their classification. All three tasks in combination require about 50 minutes.

CLAS Tenth Grade

In the animals task, students measure the pH of three water samples and compare this information with a chart showing the ideal pH for various animals. In the hot rocks task, students conduct an experiment to determine whether a given mass of water holds more heat than a given mass of rock. In the erosion task, students compare the eroding effects of neutral and acidic solutions on limestone. Students have about 50 minutes to complete the set of three tasks.

Task Administration

These hands-on performance tasks and other measures were administered in various combinations to samples of 5th, 6th, 8th, and 9th graders in California during 1993 and 1994. One of the goals of the project was to investigate the feasibility of using hands-on measures in large-scale testing programs, so we reproduced the tasks in large numbers and administered them in multiple schools and classrooms. Table 2 summarizes the administrative history of each of the tasks used in this project.

All the hands-on tasks were administered by project staff under controlled conditions. Portable partitions were used so students could not observe or otherwise interact with one another during the test sessions unless working in a group portion of the testing. Testing often occurred in the cafeteria or other large room at the school so that each student had enough space to work with a task's equipment and materials. Some hands-on tasks required an entire 50-minute class period, while others were allocated one-half or one-third of a period. The radiation and rate of cooling tasks required four class periods. Because of budgetary and logistical considerations, the shorter tasks were administered simultaneously within a classroom; i.e., some students performed one task, while others performed a different task until time was called—at which point, students rotated to a different work station for the next task.

Scoring Guides

The tasks were designed to elicit written responses from students at multiple points as they conducted their investigations. The desired responses were

Table 2

Administrative History

Task	Administered to Grade	In	Total Number of Students
Incline	5	1993	1,100
Friction	5	1993	1,100
Pendulum	6	1993	1,100
Lever	6, 8	1993–94	2,400
Classification of animals	6	1993	1,100
Classification of materials	6, 8	1993–94	2,400
Acids and Bases (alien)	8	1994	1,300
Acids and Bases (vinegar)	8	1994	1,300
Radiation	9	1993	450
Rate of cooling	9	1993	450
CLAS (rocks, roads, and critters)	5, 6	1993	1,100
CLAS (animals, hot rocks, and erosion)	9	1993	450

specified during the task development process, and they were incorporated into scoring guides that specified the number of points to be awarded for each response. During the pilot phase, both the tasks and the scoring guides were refined. Additional revisions to the scoring guides were made during the final scoring process, based on unusual or unanticipated student responses; these are the versions presented here. (The scoring guide for classification of materials was changed to make it more efficient when the task was used for the second time in 1994, and both versions are included.) The CLAS science tests used a slightly different approach to scoring to make them consistent with the broader state testing program.

We were able to achieve a high degree of agreement between readers using these scoring guides (see Table 3). The mean correlation between two readers on a hands-on task ranged from .83 to .98. The median was .95. All of the non-CLAS tasks had inter-reader correlations of .92 or higher. The exceptionally high agreement probably stemmed from a combination of factors, including designing and testing the scoring rubrics in conjunction with task development, having several separately scored segments within each measure, the use of a detailed

Table 3

Inter-Reader Correlations by Task and Grade Level

Measure	Grade 5	Grade 6	Grade 8	Grade 9
Incline	.95	—	—	—
Friction	.94	—	—	—
CLAS—Rocks	.95	.88	—	—
CLAS—Roads	.86	.83	—	—
CLAS—Critters	.85	.85	—	—
Pendulum	—	.95	—	—
Lever	—	.94	.95	—
Classification (tuning task)	—	.97	.97	—
Classification of animals	—	.93	—	—
Classification of materials	—	.92	.95	—
Acids and Bases—vinegar (discovery)	—	—	.95	—
Acids and Bases—vinegar (recipe)	—	—	.95	—
Acids and Bases—vinegar (text)	—	—	.95	—
Acids and Bases—alien (discovery)	—	—	.93	—
Acids and Bases—alien (recipe)	—	—	.96	—
Acids and Bases—alien (text)	—	—	.98	—
Radiation	—	—	—	.97
Rate of cooling	—	—	—	.98
CLAS 10th Grade	—	—	—	.87

NOTES: In grade 6, the same tuning module was used for both classification tasks. The tabled value corresponds to the first time the student took this module.

In grades 8 and 9, tabled values for non-CLAS hands-on tasks indicate the correlation between the first and second readings of a student's answers (even though within a reading, the grader who scored one portion of a student's answer booklet was usually not the same individual who scored the other portion of that booklet because there were separate reader teams for each section).

semi-analytic scoring guide, reader selection and retention policies, and extensive reader training and supervision by project staff.

Presentation of Materials

The documentation for each task is organized as follows:

- Introduction: a brief description of the key characteristics of the investigation in conceptual terms, as well as comments about the types of skills students were asked to demonstrate.
- Shell: the general blueprint from which specific tasks were developed.
- Equipment: a photograph of the equipment or apparatus accompanying each task booklet. (The Acids and Bases shell task descriptions also include tables of solution concentrations.)
- Task booklet: the exact questions and instructions given to each student.
- Scoring guide: specific instructions for awarding points to student responses for each task.
- Rating sheets: forms for recording points awarded by raters.

The appendix contains survey forms used to gather "opportunity-to-learn" information from students and teachers. Two versions of the teacher questionnaire are included (1993 and 1994). The student survey was administered in 1994 only.

2. Incline

The incline task was designed by the University of California, Santa Barbara, and administered to fifth grade students in 1993. It is one of two tasks from the Force and Motion shell. The shell outlines a structure for producing tasks at three different levels of inquiry—low, medium, and high; it has four components: planning and design, performance, analysis and interpretation, and application. The incline and friction tasks were derived from this shell using the medium level of inquiry. In the incline task, the students are introduced to the apparatus (a small truck pulled up an inclined plane by a string attached to a cup that can be filled with washers) and the independent variables (weight placed in the truck and slope of the incline). Students are asked to formulate a hypothesis about the relationship between the weight of the truck and the number of washers required to pull it. Then they are asked to design an experiment to test a hypothesis about the effect of the incline's slope on this relationship. Students perform the experiment. When students complete Part I, their booklets are collected and they are each given a new booklet for Part II. Part II contains a set of results from an experiment correctly designed to test the incline slope hypothesis. Students are asked to graph these data and draw conclusions. Finally, students are asked to apply the findings to a practical situation.

The components of the incline task will be found on the following pages:

Table 4
Planning and Design Item Shell

	LEVEL OF INQUIRY			
STEP	**NO**	**LOW**	**MEDIUM**	**HIGH**
1	Provide equipment/ material-include 1 relevant independent variable (A).	Provide equipment/material-include 1 relevant independent variable (A).	Provide equipment-include 2 relevant independent variables (A, B) & 1 irrelevant independent variable (C) if appropriate.	Provide equipment-include 2 relevant independent variables (A, B) & 1 irrelevant independent variable (C) if appropriate.
2	Let students play around with the equipment. Introduce variable names.	Let students play around with the equipment. Introduce variable names.	Let students play around with the equipment. Introduce variable names.	Let students play around with the equipment. Introduce variable names.
3	State a hypothesis involving independent variable A.	Provide a hypothesis involving independent variable A.	Provide a problem involving independent variable B.	Ask students to formulate a problem or hypothesis by defining the need for: -New knowledge on facts, data, or properties of objects or events, or -An explanation of facts or ideas, or -A verification of facts or ideas, or By stating: -A goal, or -A condition resulting from the solution.

Table 4—continued

	LEVEL OF INQUIRY			
STEP	**NO**	**LOW**	**MEDIUM**	**HIGH**
4	Demonstrate an experiment to test the hypothesis.	Ask students to design an experiment to test the hypothesis.	Ask students to formulate a hypothesis regarding independent variable B to: —Generalize an experience, or —Elaborate an inference, or —Guide their research work, or —Interpret information, or —Predict a relation between variables, or —Justify existing data, or —Use open-ended question.	Transition to the next step.
5	Ask students to write the sequence of actions of the experiment.	Ask students to write the sequence of actions of the experiment.	Transition to next step.	Provide a hypothesis involving independent variable A.
6	END	END	Provide a hypothesis involving independent variable A.	Ask students to design an experiment to test the hypothesis.
7			Ask students to design an experiment to test the hypothesis.	Ask students to write the sequence of actions of the experiment.
8			Ask students to write the sequence of actions of the experiment.	END
9			END	

Table 5

Performance Item Shell

	LEVEL OF INQUIRY			
STEP	NO	LOW	MEDIUM	HIGH
1	Pose a problem or a hypothesis involving 1 relevant independent variable (A).	Pose a problem or a hypothesis involving 1 relevant independent variable (A).	Pose a problem or a hypothesis involving 1 relevant independent variable (A).	Pose a problem or a hypothesis involving 1 relevant variable (A) and 1 irrelevant independent variable (B) if appropriate.
2	Do and explain manipulations and measurements.	Provide equipment–include independent variable A. Introduce variable names.	Provide equipment–include independent variable A. Introduce variable names.	Provide equipment–include independent variable A and independent variable B. Introduce variable names.
3	Ask students to watch.	Tell the students which manipulations should be done and how they should be done.	Ask the students to solve the problem or test the hypothesis.	Ask the students to solve the problem or test the hypothesis.
4	Ask students to report manipulations, measurements, and results. Provide table/chart.	Ask the students to solve the problem or test the hypothesis.	Ask the students to report manipulations, measurements, and results. Provide table/chart.	Ask the students to report manipulations, measurement and results.
5	If Analysis & Interpretation item shell does <u>not</u> follow, ask students to interpret results.	Ask the students to report manipulations, measurements, and results. Provide table/chart.	If Analysis & Interpretation item shell does <u>not</u> follow, ask students to interpret results.	If Analysis & Interpretation item shell does <u>not</u> follow, ask students to interpret results.
6	END	If Analysis & Interpretation item shell does <u>not</u> follow, ask students to interpret results.	END	END
7		END		

Table 6
Analysis and Interpretation Item Shell

	LEVEL OF INQUIRY			
STEP	NO	LOW	MEDIUM	HIGH
1	a) Describe a problem or a hypothesis that is related to the concept previously assessed. b) Describe a study on that problem or hypothesis in terms of a qualitative or quantitative relation between variables. c) Provide data from that study.	a) Describe a problem or a hypothesis that is related to the concept previously assessed. b) Describe a study on that problem or hypothesis in terms of a qualitative or quantitative relation between variables. c) Provide data from that study.	a) Describe a problem or a hypothesis that is related to the concept previously assessed. b) Describe a study on that problem or hypothesis in terms of a qualitative or quantitative relation between variables. c) Provide data from that study.	a) Describe a problem or a hypothesis that is related to the concept previously assessed. b) Describe a study on that problem or hypothesis in terms of a qualitative or quantitative relation between variables. c) Provide data from that study.
2	Provide an organized set of data (e.g., table, graph, diagram) showing the relationship.	Provide an organized set of data (e.g., table, graph, diagram) showing the relationship.	Ask the students to: -rearrange, or -transform, or -collapse, or -compute, or -synthesize the data set in a labeled table / graph / diagram given to them in order to show the relationship.	Ask the students to: -rearrange, or -transform, or -collapse, or -compute, or -synthesize the data set in a table / graph / diagram to show the relationship.
3	Explain the relationship.	Ask the students to describe the relationship in words.	Ask the students to draw a conclusion about the study and the relationship found.	Ask the students to draw a conclusion about the study and the relationship found.
4	Ask the students to draw a conclusion about the study and the relationship found.	Ask the students to draw a conclusion about the study and the relationship found.	END	END
5	END	END		

25 26

Table 7
Application Item Shell

STEP	LEVEL OF INQUIRY: NO	LOW	MEDIUM	HIGH
1	Provide a concrete, meaningful context. – Create two competing situations or scenarios, one of which involves the scientific concept of interest.	Provide a concrete, meaningful context. – Create two competing situations or scenarios, one of which involves the scientific concept of interest.	Provide a concrete, meaningful context. – Create two competing situations or scenarios, one of which involves the scientific concept of interest.	Provide a concrete, meaningful context. – Create two competing situations or scenarios, one of which involves the scientific concept of interest.
2	Provide either a "pure science" problem (e.g., description, measurement, classification) or a problem of social or practical interest (e.g., water pollution, trash dumps) whose solution can be accomplished by using part or the totality of knowledge previously taught on the same domain of science knowledge.	Provide either a "pure science" problem (e.g., description, measurement, classification) or a problem of social or practical interest (e.g., water pollution, trash dumps) whose solution can be accomplished by using part or the totality of knowledge previously taught on the same domain of science knowledge.	Provide either a "pure science" problem (e.g., description, measurement, classification) or a problem of social or practical interest (e.g., water pollution, trash dumps) whose solution can be accomplished by using part or the totality of knowledge previously taught on the same domain of science knowledge.	Provide either a "pure science" problem (e.g., description, measurement, classification) or a problem of social or practical interest (e.g., water pollution, trash dumps) whose solution can be accomplished by using part or the totality of knowledge previously taught on the same domain of science knowledge.
3	Provide summary of hypotheses and findings from previous assessments. Link hypotheses/findings to problem at hand.	Provide summary of hypotheses and findings from previous assessments. Link hypotheses/findings to problem at hand.	Provide summary of hypotheses and findings from previous assessments. Link hypotheses/findings to problem at hand.	Provide summary of hypotheses and findings from previous assessments.

Table 7—continued

STEP	LEVEL OF INQUIRY: NO	LOW	MEDIUM	HIGH
4	If problem chosen is a "pure science" issue, then provide relevant equipment for demonstration. If not, proceed to next step.	If problem chosen is a "pure science" issue, then provide relevant equipment for demonstration. If not, proceed to next step.	If problem chosen is a "pure science" issue, then provide relevant equipment for demonstration. If not, proceed to next step.	If problem chosen is a "pure science" issue, then provide relevant and irrelevant equipment for demonstration. If not, proceed to next step.
5	Demonstrate and explain the solution to the problem.	Give hints for the solution of the problem. Make specific parallels between findings from previous assessments and problem at hand.	Ask the students: 1) to show a product for the solution of the problem, or 2) to give the steps that lead them to the solution, or 3) to identify the advantages of the solution, or 4) to suggest possible alternative solutions.	Ask the students: 1) to show a product for the solution of the problem, or 2) to give the steps that lead them to the solution, or 3) to identify the advantages of the solution, or 4) to suggest possible alternative solutions.
6	Ask the students: 1) to show a product for the solution of the problem, or 2) to give the steps that lead them to the solution, or 3) to identify the advantages of the solution, or 4) to suggest possible alternative solutions.	Ask the students: 1) to show a product for the solution of the problem, or 2) to give the steps that lead them to the solution, or 3) to identify the advantages of the solution, or 4) to suggest possible alternative solutions.	END	END
7	END	END		

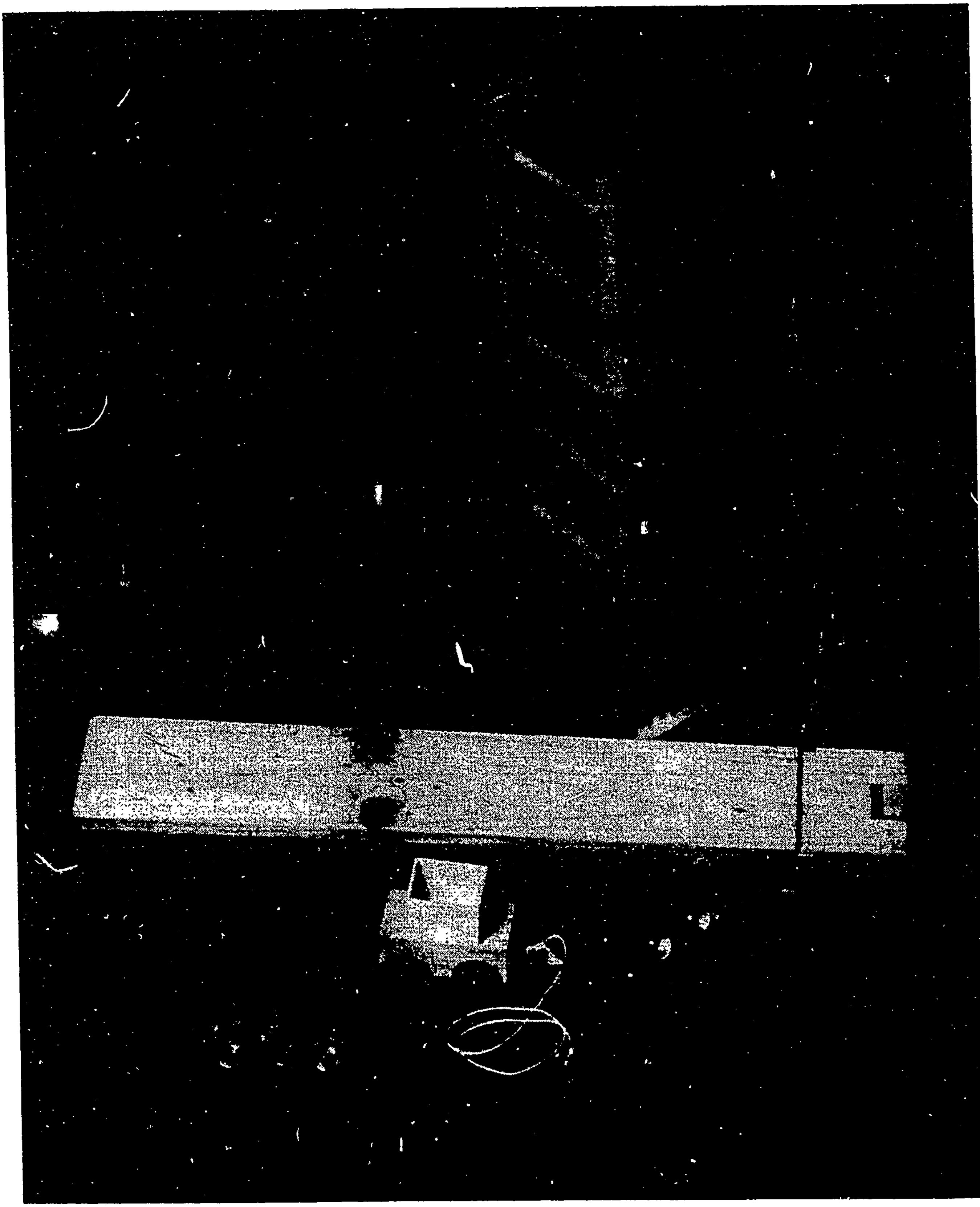


Figure 1—Equipment for Incline

Task page 1

INCLINE
PERFORMANCE ASSESSMENT
SECTION I

Your Name: ____
(Last) (First)

Boy or Girl
(please circle)

Date of Birth: ____________________
month day year

Today's Date: ____________________
month day year

INSTRUCTIONS

In this activity you will be working by yourself. Read each page carefully. Answer all the questions in the spaces provided.

GO TO NEXT PAGE

Task page 2

PART I: *Planning and Design*

Please take the equipment out of the bag in front of you. You should have the following things:

EQUIPMENT

Inclined plane with ladder

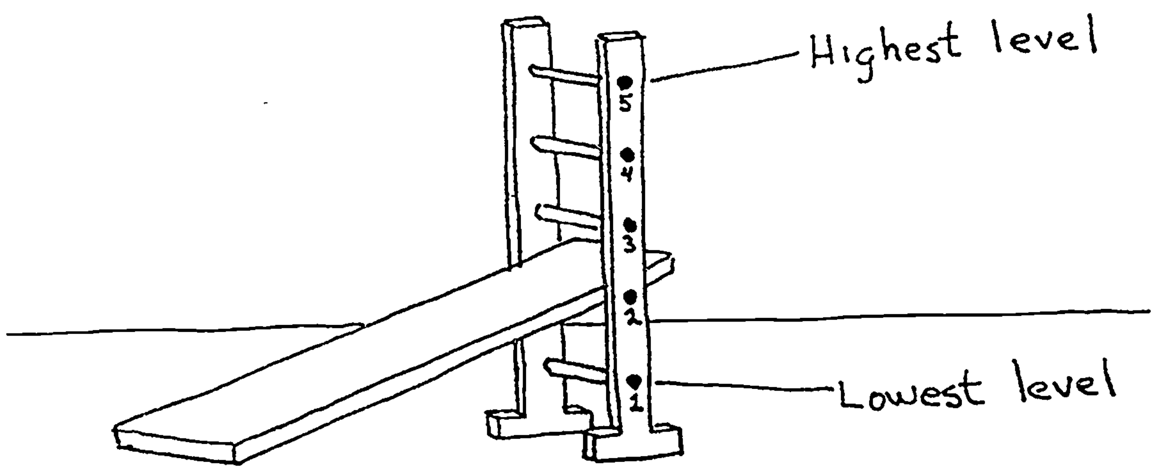
Truck with string and hook

Bucket

4 Marbles -2 large
-2 small

35 Metal washers

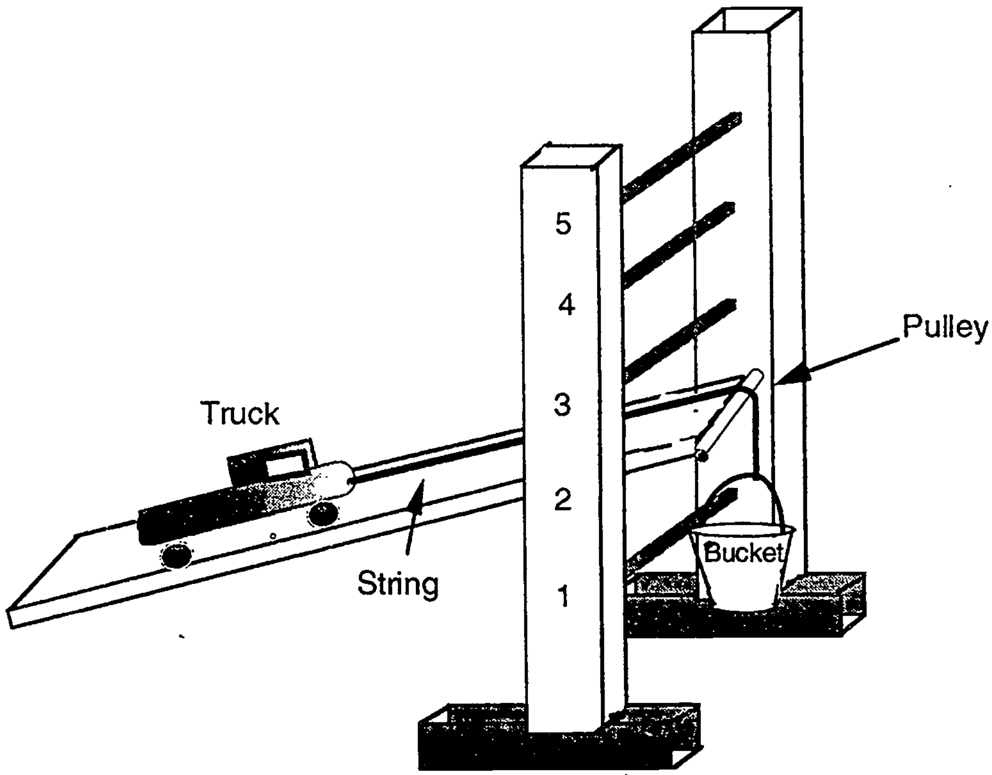
Set up the inclined plane and the ladder so that the inclined plane is at level 2. It should look like this:



GO TO NEXT PAGE

Task page 3

Put the truck on the inclined plane. Run the string underneath the rung of the ladder and <u>over</u> the pulley (spool) so that the hook hangs down over the inclined plane. Put the bucket on the hook. It should look like this:



Practice pulling the truck up the inclined plane by putting washers in the bucket. ***The bucket should drop down to the table.***

The number of washers in the bucket is a measure of the amount of **force** needed to pull the truck up the inclined plane.

MORE WASHERS = MORE FORCE

Now let's think of how we would solve some problems using the inclined plane.

GO TO NEXT PAGE

Task page 4

Frank and **Al** are wondering if they need *more* force or *less* force to pull the truck up the inclined plane when they change the weight of the truck.

Suppose you add two large marbles to the truck. Will you have to put more washers, less washers, or the same number of washers in the bucket to pull the truck up the inclined plane?

____

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How does the amount of force you use to pull the truck up the inclined plane change when:

the truck is heavier? ___________________________

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the truck is lighter? ___________________________

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GO TO NEXT PAGE

Task page 5

Now let's think about a *different* problem.

Frank and **Al** have different ideas about how much force they would need to pull the truck up the inclined plane when the inclined plane is at different levels of the ladder.

Frank thinks that it takes more force to pull the truck up the inclined plane when the inclined plane is at a higher level than when it is at a lower level.

BUT

Al thinks that the level of the inclined plane does not matter. He thinks that it takes the same amount of force to pull the truck up the inclined plane at any level.

Can you think of an **experiment** you could do to test who is right? You can use the equipment in front of you to figure out how you could design an experiment.

BELOW, write down the steps you would follow to do your experiment (If you need more space, you can write on the back of this page).

1 ______________________________

GO TO NEXT PAGE

Task page 6

PART II: *Performance*

Now let's see who is right.

REMEMBER:

Frank thinks that it takes more force to pull a truck up an inclined plane when the inclined plane is at a higher level than when it is at a lower level.

BUT

Al thinks that the level of the inclined plane does not matter. He thinks that it takes the same amount of force to pull the truck up the inclined plane at any level.

Use the equipment in front of you to test who is right, Frank or Al.
Write down your results in the table below.

LEVEL (Level of Ladder)	FORCE (Number of Washers)

PLEASE RAISE YOUR HAND
FOR SECTION II OF THE TEST

Task page 1

INCLINE
PERFORMANCE ASSESSMENT
SECTION II

Your Name: ______________________________________

(Last) (First)

GO TO NEXT PAGE

Task page 2

PART III: *Analysis and Interpretation*

Frank and **Al** did an experiment to test their ideas about the inclined plane. This is what they did:

1. They set up the inclined plane at level 1 of the ladder. They set up the truck on the inclined plane.

2. They added washers one by one to the bucket until the bucket fell down to the table. They wrote down the total number of washers it took to make the bucket drop down to the table.

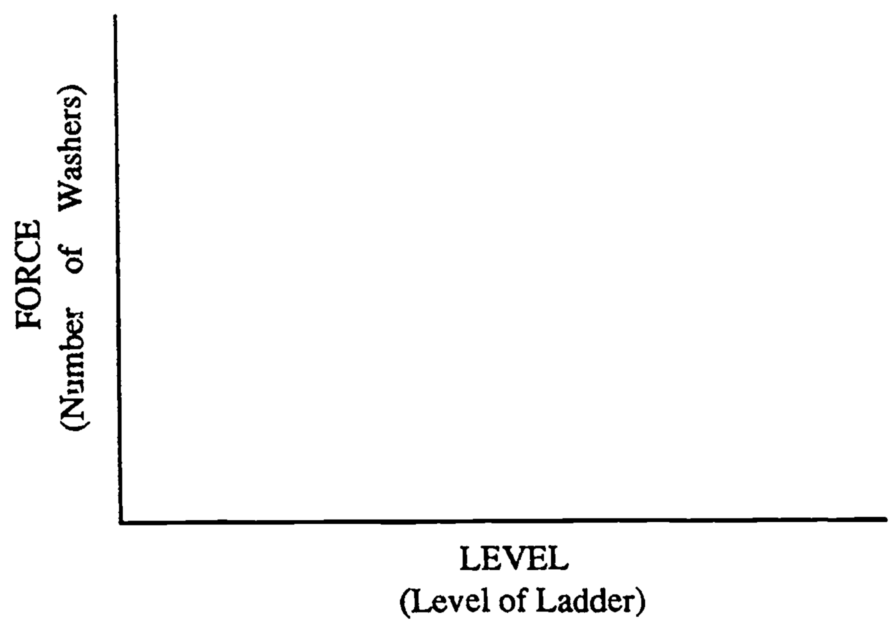
3. They repeated steps 1 and 2 for each level of the ladder. They *always* returned the bucket to the top before putting the washers in.

GO TO NEXT PAGE

Frank and **Al** wrote down their results in the table below.

LEVEL (Level of Ladder)	FORCE (Number of Washers)
1	3
2	7
3	12
4	15
5	20

Use the information from the table to graph the findings from Frank's and Al's experiment.



GO TO NEXT PAGE

Task page 4

Look at Frank and Al's results. How did the amount of force needed to pull the truck up the inclined plane change when the level increased?

Remember: Frank thought that it would take more force to pull the truck up the inclined plane when it is at a higher level than a lower level. Al thought that the amount of force needed to pull the truck would be the same at any level.

So who was right, Frank or Al? ______________________________

How could you tell from the experiment who was right? __________

GO TO NEXT PAGE

Task page 5

PART IV: *Application*

Your town has to decide **where** it will dump its garbage. The Hill dump is 10 miles away, but the garbage trucks have to go up a steep mountain to get there. The Level dump is also 10 miles away, but there are no hills to climb to get there.

The Hill dump charges **$45** for each ton of garbage it receives. The Level dump charges **$50** for each ton.

Also, your town has to pay for the **gasoline** the trucks use to take the garbage to the dump. (More gasoline = more force).

Which dump would cost the town more to use? Please circle your answer.

a. Hill dump would cost more
b. Level dump would cost more
c. Both dumps would cost the same
d. Cannot tell which dump would cost more

Use what you learned from **Frank** and **Al's** experiment to **explain the reason for your answer:**

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Scoring Guide - Incline Plane

Section I

Page	Item	Possible Points	Scoring Criteria
4	1	1	1 pt for a statement such as: more washers in the bucket more force more washers more or gives actual quantities that show the correct trend
4	2	1	1 pt for a statement such as: more washers used when truck is heavier more washers more force more pull or gives actual quantities that show the correct trend
4	3	1	1 pt for a statement such as: less washers used when truck is lighter less washers less force less pull or gives actual quantities that show correct trend

5	1a	0	**A:** Response **describes a design** for the experiment, but does not show that the student actually carried out the experiment at this stage. **B:** Response indicates that the student **actually performed the experiment** (and hence implicitly designed it). **If it is not clear whether Option A or B is appropriate, use whichever option yields the highest score. The default is Option A.** **C:** The response is **blank, incomprehensible** or the response only **gives a conclusion**.
5	1	3	**A:** Response **describes a design** . **Then score as follows:** 1 pt: a reasonable part, oı step, of running the experiment is mentioned, not including counting washers or repeating the steps across levels. There should be some explicit statement which cues this, such as "set the plane on the ladder" or "pull string over pulley" 1 pt: says to count the number of washers on the hook. This may also be implicit, if the actual counts of washers are mentioned, or statements like "more than", "less than" and "in between" are used. 1 pt: mentions doing the same operations for <u>at least two</u> <u>levels of the ladder</u>. **B:** student **actually performed the experiment** . **Then score as follows:** 1 pt: something is said about the procedures used. 1 pt: the number of washers in the bucket are counted. 1 pt: repeats the operations for <u>at least two levels</u>. **C:** The response is **blank, incomprehensible** or only **gives a conclusion**. Zero points.
6	1	3	1 pt: Includes at least 2 levels of the ladder. 1 pt: Provides a number of washers for every level of the ladder included. 1 pt: The number of washers increases as the level increases.

Rater Answer Form – Incline
Section I

Rater Name:______________________ Date: July __________, 1993

Rater ID Number:_________________ Starting Time:_____:_____AM/PM

Instructions: Circle the number of points awarded for each question.

Student ID Number	p4/Item 1	p4/Item 2	p4/Item 3	p5/Item 1		p6/Item 1
_____ - _____ - _____ - 33	0 1	0 1	0 1	A B C	0 1 2 3 4	0 1 2 3
_____ - _____ - _____ - 33	0 1	0 1	0 1	A B C	0 1 2 3 4	0 1 2 3
_____ - _____ - _____ - 33	0 1	0 1	0 1	A B C	0 1 2 3 4	0 1 2 3
_____ - _____ - _____ - 33	0 1	0 1	0 1	A B C	0 1 2 3 4	0 1 2 3
_____ - _____ - _____ - 33	0 1	0 1	0 1	A B C	0 1 2 3 4	0 1 2 3
_____ - _____ - _____ - 33	0 1	0 1	0 1	A B C	0 1 2 3 4	0 1 2 3
_____ - _____ - _____ - 33	0 1	0 1	0 1	A B C	0 1 2 3 4	0 1 2 3
_____ - _____ - _____ - 33	0 1	0 1	0 1	A B C	0 1 2 3 4	0 1 2 3
_____ - _____ - _____ - 33	0 1	0 1	0 1	A B C	0 1 2 3 4	0 1 2 3
_____ - _____ - _____ - 33	0 1	0 1	0 1	A B C	0 1 2 3 4	0 1 2 3
_____ - _____ - _____ - 33	0 1	0 1	0 1	A B C	0 1 2 3 4	0 1 2 3
_____ - _____ - _____ - 33	0 1	0 1	0 1	A B C	0 1 2 3 4	0 1 2 3
_____ - _____ - _____ - 33	0 1	0 1	0 1	A B C	0 1 2 3 4	0 1 2 3
_____ - _____ - _____ - 33	0 1	0 1	0 1	A B C	0 1 2 3 4	0 1 2 3
_____ - _____ - _____ - 33	0 1	0 1	0 1	A B C	0 1 2 3 4	0 1 2 3
_____ - _____ - _____ - 33	0 1	0 1	0 1	A B C	0 1 2 3 4	0 1 2 3
_____ - _____ - _____ - 33	0 1	0 1	0 1	A B C	0 1 2 3 4	0 1 2 3
_____ - _____ - _____ - 33	0 1	0 1	0 1	A B C	0 1 2 3 4	0 1 2 3
_____ - _____ - _____ - 33	0 1	0 1	0 1	A B C	0 1 2 3 4	0 1 2 3
_____ - _____ - _____ - 31	0 1	0 1	0 1	A B C	0 1 2 3 4	0 1 2 3

45

46

Scoring Guide - Incline Plane
Section II

Page	Item	Possible Points	Scoring Criteria
3	1	4	1 pt: all the levels of the ladder are represented in order on the horizontal axis. 1 pt: an equal interval scale is given for the force axis (may be increasing or decreasing) 1 pt: all the values from the table are plotted (the type of graph does not matter) 1 pt: at least 4 values are represented correctly on the graph.
4	5	1	1 pt: force increased more washers pull harder
4	6	1	1 pt: Frank was right
4	7	1	1 pt: force increased (more washers) as slope increased answers are different and increasing
5	1	4	1 pt: recognizes that it takes more force (more gas) to go a hill than along the flat 1 pt: recognizes that the difference in charges at the two dumps may offset other costs 1 pt: recognition of additional factors 1 pt: a logical inference is made, either in writing or with reference to the circled answer above

Example 1

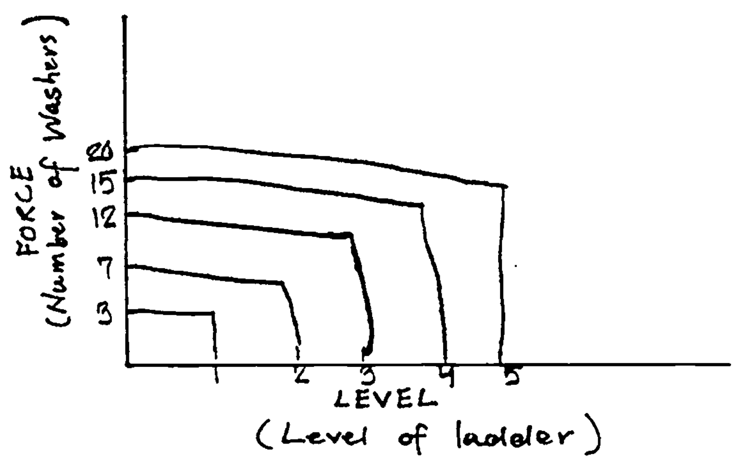
The following graph would receive a score of 2 points.

Point for....	Points Received
Horizontal Axis:	1
Vertical Axis:	0 (not clearly equal interval)
Plotting all the points:	1 -- for this point and the last point a combined total of 1 point is given because of the 90 degree lines in the graph.
Plotting the points correctly:	See above point
Total Points	2

Frank and Al wrote down their results in the table below.

LEVEL (Level of Ladder)	FORCE (Number of Washers)
1	3
2	7
3	12
4	15
5	20

Use the information from the table to graph the findings from Frank's and Al's experiment.



GO TO NEXT PAGE

Example 2

The following graph would receive a score of 0 points.

<u>Point</u> <u>for....</u> — <u>Points</u> <u>Received</u>

Horizontal Axis: No graph, no points.
(The chart merely is inverted and placed in the
graph.)

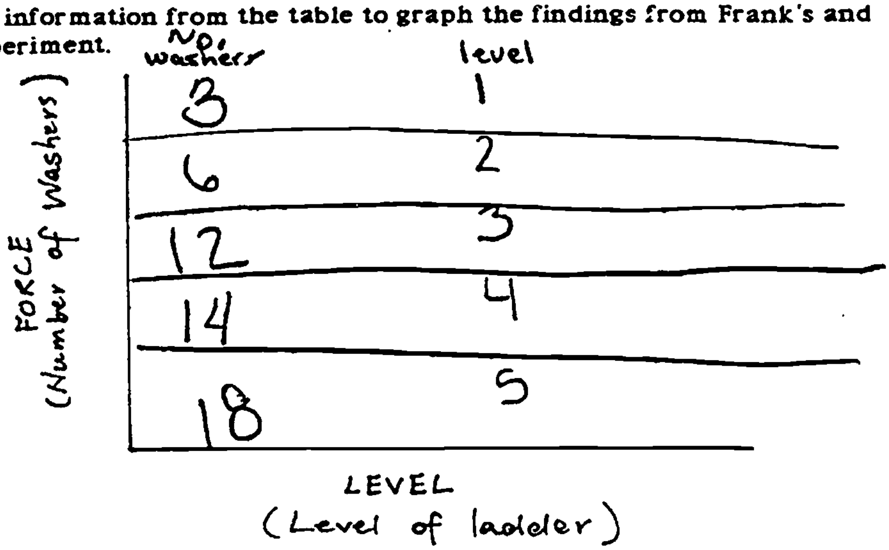
Vertical Axis:
Plotting all the points:
Plotting the points correctly:

<u>Total</u> <u>Points</u> 0

Frank and Al wrote down their results in the table below.

LEVEL (Level of Ladder)	FORCE (Number of Washers)
1	3
2	7
3	12
4	15
5	20

Use the information from the table to graph the findings from Frank's and Al's experiment.



Example 3

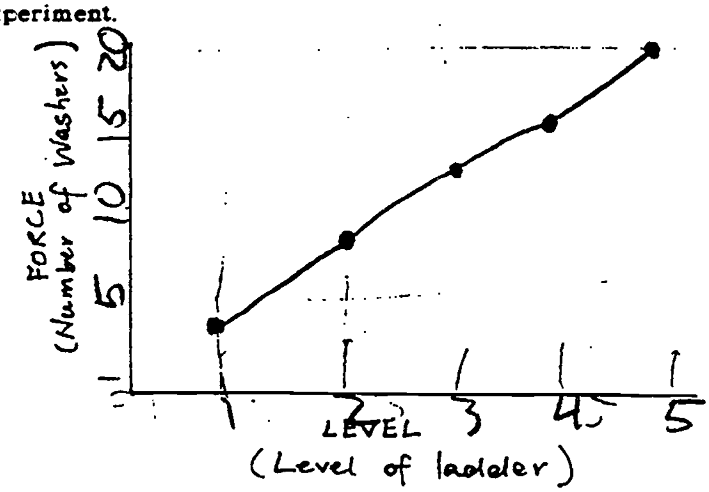
The following graph would receive a score of 4 points.

Point for....	Points Received
Horizontal Axis:	1
Vertical Axis:	1 (clearly equal interval)
Plotting all the points:	1 -- While 90 degrees lines are in the graph, there is a clear line graph
Plotting the points correctly:	1
Total Points	4

Frank and Al wrote down their results in the table below.

LEVEL (Level of Ladder)	FORCE (Number of Washers)
1	3
2	7
3	12
4	15
5	20

Use the information from the table to graph the findings from Frank's and Al's experiment.



GO TO NEXT PAGE

Example 4

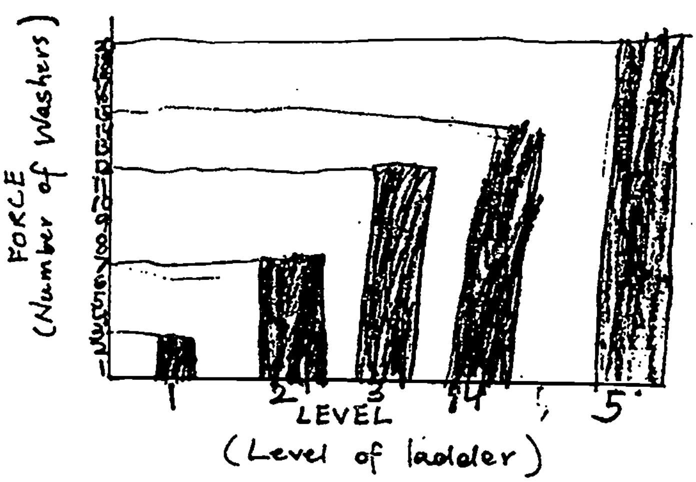
The following graph would receive a score of 4 points.

Point for....	Points Received
Horizontal Axis:	1
Vertical Axis:	1 (clearly equal interval)
Plotting all the points:	1 -- While 90 degrees lines are in the graph, there is a clear bar graph
Plotting the points correctly:	1
Total Points	4

Frank and Al wrote down their results in the table below.

LEVEL (Level of Ladder)	FORCE (Number of Washers)
1	3
2	7
3	12
4	15
5	20

Use the information from the table to graph the findings from Frank's and Al's experiment.



GO TO NEXT PAGE

Example 5

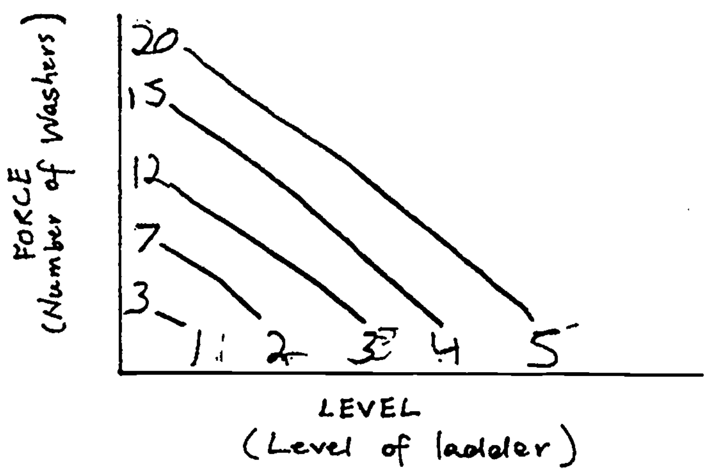
The following graph would receive a score of 1 point.

Point for....	Points Received
Horizontal Axis:	1
Vertical Axis:	0 (clearly not equal interval)
Plotting all the points:	0 -- there is no plot of a "graph point," even though there is a
connection of horizontal and	the values on the vertical axis
Plotting the points correctly:	0
Total Points	1

Frank and Al wrote down their results in the table below.

LEVEL (Level of Ladder)	FORCE (Number of Washers)
1	3
2	7
3	12
4	15
5	20

Use the information from the table to graph the findings from Frank's and Al's experiment.



GO TO NEXT PAGE

Rater Answer Form - Incline
Section II

Rater Name:____________________ Date: July ________, 1993

Rater ID Number:______________ Starting Time:____:____AM/PM

Instructions: Circle the number of points awarded for each question.

Student ID Number	p3/Item 1	p4/Item 1	p4/Item 2	p4/Item 3	p5/Item 1
_____ - _____ - _____ - 34	0 1 2 3 4	0 1	0 1	0 1	0 1 2 3
_____ - _____ - _____ - 34	0 1 2 3 4	0 1	0 1	0 1	0 1 2 3
_____ - _____ - _____ - 34	0 1 2 3 4	0 1	0 1	0 1	0 1 2 3
_____ - _____ - _____ - 34	0 1 2 3 4	0 1	0 1	0 1	0 1 2 3
_____ - _____ - _____ - 34	0 1 2 3 4	0 1	0 1	0 1	0 1 2 3
_____ - _____ - _____ - 34	0 1 2 3 4	0 1	0 1	0 1	0 1 2 3
_____ - _____ - _____ - 34	0 1 2 3 4	0 1	0 1	0 1	0 1 2 3
_____ - _____ - _____ - 34	0 1 2 3 4	0 1	0 1	0 1	0 1 2 3
_____ - _____ - _____ - 34	0 1 2 3 4	0 1	0 1	0 1	0 1 2 3
_____ - _____ - _____ - 34	0 1 2 3 4	0 1	0 1	0 1	0 1 2 3
_____ - _____ - _____ - 34	0 1 2 3 4	0 1	0 1	0 1	0 1 2 3
_____ - _____ - _____ - 34	0 1 2 3 4	0 1	0 1	0 1	0 1 2 3
_____ - _____ - _____ - 34	0 1 2 3 4	0 1	0 1	0 1	0 1 2 3
_____ - _____ - _____ - 34	0 1 2 3 4	0 1	0 1	0 1	0 1 2 3
_____ - _____ - _____ - 34	0 1 2 3 4	0 1	0 1	0 1	0 1 2 3
_____ - _____ - _____ - 34	0 1 2 3 4	0 1	0 1	0 1	0 1 2 3
_____ - _____ - _____ - 34	0 1 2 3 4	0 1	0 1	0 1	0 1 2 3
_____ - _____ - _____ - 34	0 1 2 3 4	0 1	0 1	0 1	0 1 2 3
_____ - _____ - _____ - 34	0 1 2 3 4	0 1	0 1	0 1	0 1 2 3
_____ - _____ - _____ - 34	0 1 2 3 4	0 1	0 1	0 1	0 1 2 3

3. Friction

The friction task was designed by UCSB and administered to fifth-grade students in 1993. The shell used for designing the task is identical to that for the incline task (see Section 2). It has four components: planning and design, performance, analysis and interpretation, and application. In the friction task, the students are introduced to the apparatus (a wooden block pulled across a board by a string attached to a number of washers) and the independent variables (block weight and board texture). Students are asked to formulate a hypothesis about the relationship between block weight and the number of washers required to pull it. Then they are asked to design an experiment to test a hypothesis about the effect of board texture on this relationship. Students perform the experiment. Next, the students are given a set of results from an experiment correctly designed to test the board texture hypothesis and are asked to graph them and draw conclusions. Finally, students are asked to apply the findings to a practical situation.

The components of the friction task will be found on the following pages:

(Note: As an aid in scoring the friction task, raters were given the examples from the incline task, which is scored analogously.)

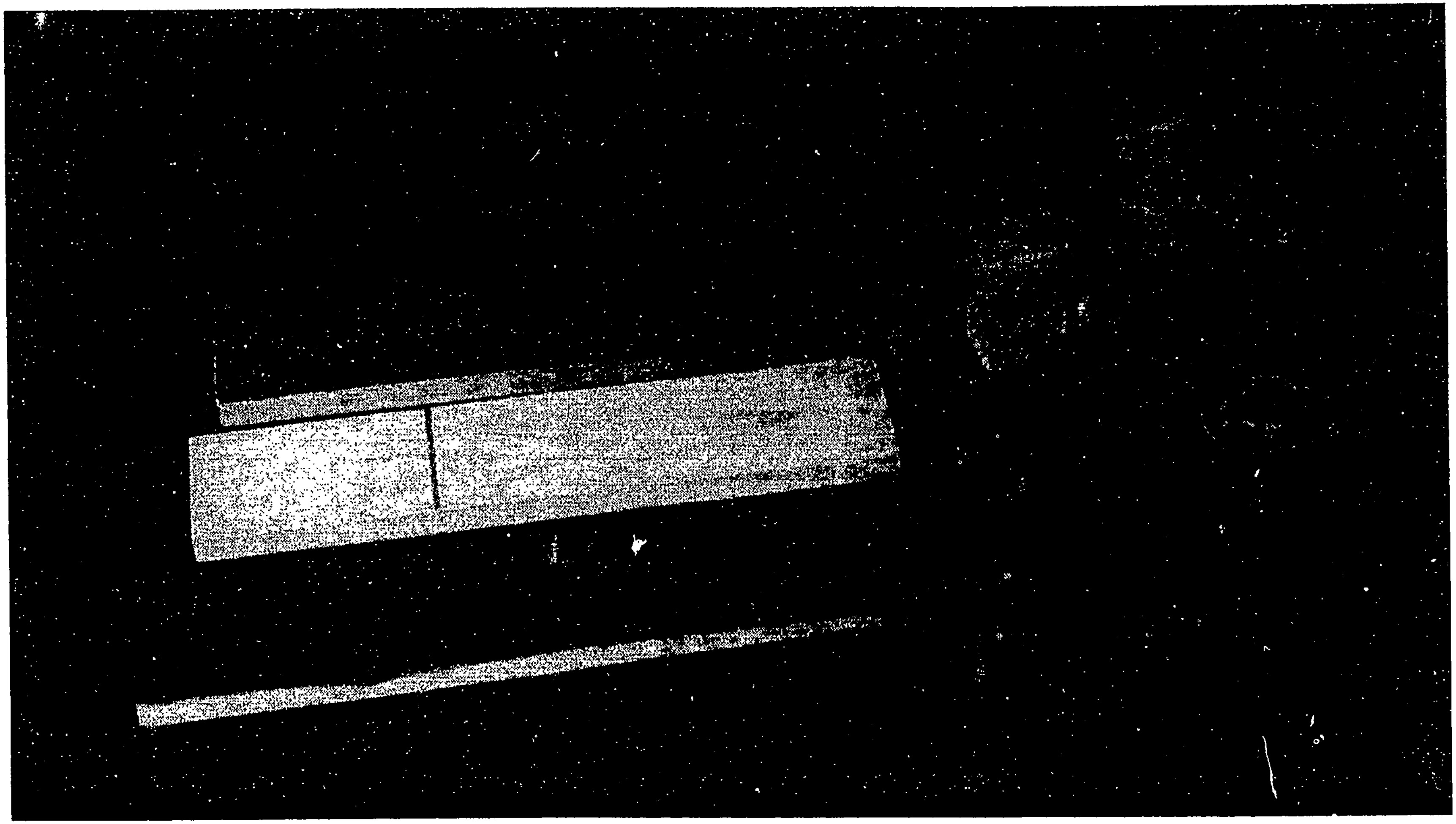


Figure 2—Equipment for Friction

Task page 1

FRICTION
PERFORMANCE ASSESSMENT
SECTION I

Your Name: ____
(Last) (First)

Boy or Girl
(please circle)

Date of Birth: ______________________
month day year

Today's Date: ______________________
month day year

INSTRUCTIONS

In this activity you will be working by yourself. Read each page carefully. Answer all the questions in the spaces provided.

GO TO NEXT PAGE

Task page 2

PART I: *Planning and Design*

Please take the equipment out of the bag in front of you. You should have the following things.

EQUIPMENT

2 wooden blocks with hooks

String with hook

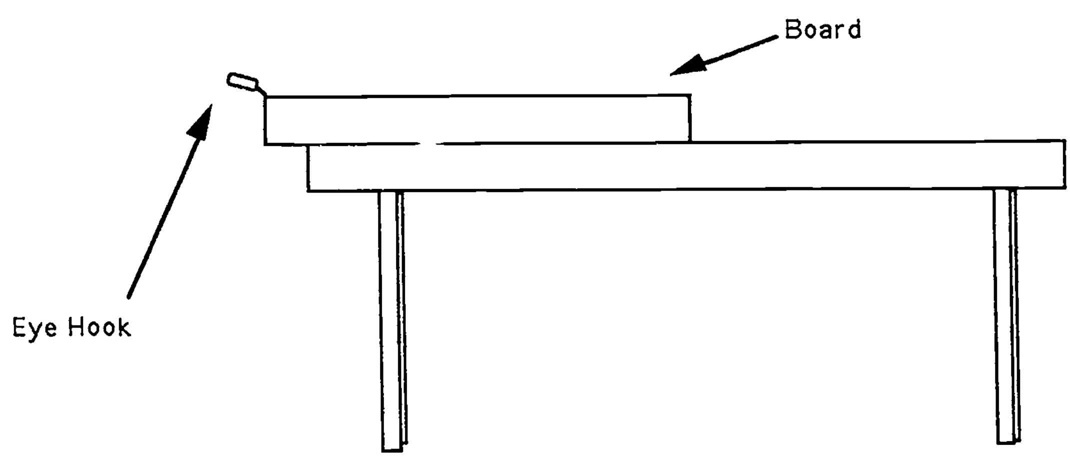
1 plain wood board with eye hook

1 felt covered board with eye hook

1 sandpaper covered board with eye hook

35 Metal washers

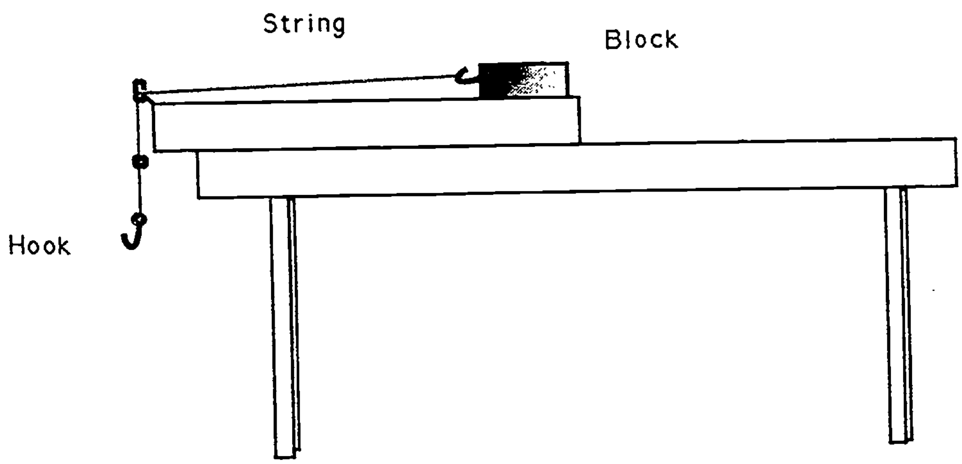
Put the plain wood board on the table so that the end of the board with the eye hook hangs over the table. It should look like this:



GO TO NEXT PAGE

Task page 3

Now put **one of the blocks** with the "**B**" side down on the board. Place it behind the red starting line. Take the string with the big metal hook and pull it through the small eye hook. Now loop the string on to the hook on the block. It should look like this:



Notice that the blocks are different **weights** and the boards have different **surface textures**.

Practice pulling one of the blocks along the board by putting washers on the hook. ***The back end of the block should cross the starting line.***

The number of washers on the hook is a measure of the amount of **force** needed to pull the blocks.

MORE WASHERS = MORE FORCE

Now let's think of how you would solve some problems using the blocks and boards.

GO TO NEXT PAGE

Task page 4

Maria and **Sue** want to know if they will need different amounts of force to pull blocks of different weights along the plain wood board.

Suppose it takes 4 washers to pull the lighter block. Will you have to put more washers, less washers, or the same number of washers on the hook to pull the heavier block?

____

____

____

How does the amount of force you use to pull the block change when:

the block is heavier? ___________________________

____

____

the block is lighter? ___________________________

____

____

GO TO NEXT PAGE

Task page 5

Now let's think about a *different* problem. Let's only use the large block.

Maria and **Sue** have different ideas about how much force they need to pull a block along 3 boards.

Maria thinks that the amount of force needed to pull the block depends on the surface texture of the board. The rougher the surface, the more force she will need to pull the block.

BUT

Sue thinks that the surface texture does not matter. She thinks that the amount of force needed to pull the block will be the same for each board.

Can you think of an **experiment** you could do to test who is right? You can use the equipment in front of you to figure out how you could design an experiment.

BELOW, write down the steps you would follow to do your experiment. (If you need more space, you can write on the back of this page).

1 ____

____

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GO TO NEXT PAGE

Task page 6

PART II: *Performance*

Now let's see who is right.

REMEMBER:

Maria thinks that the amount of force needed to pull the block depends on the surface texture of the board. The rougher the surface, the more force she will need to pull the block.

BUT

Sue thinks that the surface texture does not matter. She thinks that the amount of force needed to pull the block will be the same for each board.

Use the equipment in front of you to test if who is right, Maria or Sue. Write down your results in the table below.

SURFACE TEXTURE (Board)	FORCE (Number of Washers)

PLEASE RAISE YOUR HAND
FOR SECTION II OF THE TEST

Task page 1

FRICTION
PERFORMANCE ASSESSMENT
SECTION II

Your Name: ____

(Last) (First)

GO TO NEXT PAGE

Task page 2

<u>PART III</u>: *Analysis and Interpretation*

Maria and **Sue** did an experiment to test their ideas about surface texture. This is what they did:

1. They put the block on the plain wood board behind the starting line so that the hook on the string hung over the table.

2. They added washers to the hook one by one until the back end of the block moved past the starting line. They wrote down the total number of washers it took to move the back end of the block past the starting line.

3. They repeated steps 1 and 2 with the other boards.

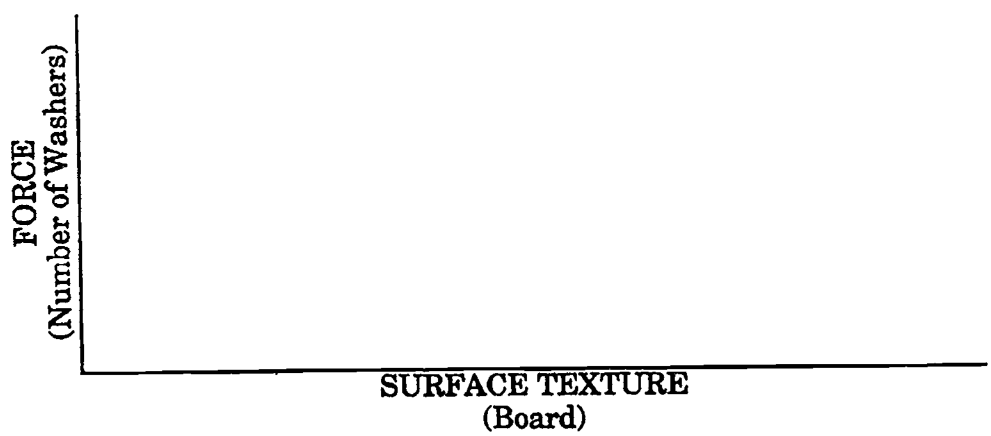
GO TO NEXT PAGE

Task page 3

Maria and **Sue** wrote down their results in the table below.

SURFACE TEXTURE (Board)	FORCE (Number of Washers)
1	3
2	7
3	12
4	15
5	20

Use the information from the table to graph the findings from Maria's and Sue's experiment.



GO TO NEXT PAGE

Task page 4

Look at Maria and Sue's results. How did the amount of force needed to pull the block change when the surface texture got rougher?

Remember: Maria thought that the amount of force needed to pull the block along a board depends upon the surface texture of the board. But Sue thought that the surface texture wouldn't matter.

So who was right, Maria or Sue

How could you tell from the experiment who was right?

GO TO NEXT PAGE

Task page 5

PART IV: *Application*

Some students at your school make wooden toys. They sell the toys to raise money for a local charity.

Terry's job is to rub each toy **100** times with a piece of **sandpaper**. Next, to make the toy even smoother, **Jody** rubs it **115** times with a **soft cloth**.

Terry and Jody each do 20 toys per day.

Which of the following statements is most true about **who works harder** in rubbing the toys (working harder = more effort)?
Please circle your answer.

a. Terry works harder than Jody
b. Jody works harder than Terry
c. Terry works as hard as Jody
d. Cannot tell who works harder

Use what you learned from **Maria** and **Sue's** experiment to **explain the reason for your answer:**

____

____

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____

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Scoring Guide - Friction

Section I

Page	Item	Possible Points	Scoring Criteria
4	1	1	1 pt for a statement such as: more washers on the hook more washers more force more or gives actual quantities that show the heavier block needs more washers
4	2	1	1 pt for a statement such as: more washers used when block is heavier pull harder more weight more force or gives actual quantities that show the heavier block needs more washers
4	3	1	1 pt for a statement such as: less washers used when block is lighter less force less weight or gives actual quantities that show the lighter block needs less washers

5	1a	0	**A:** Response **describes a design** for the experiment, but does not show that the student actually carried out the experiment at this stage. **B:** Response indicates that the student **actually performed the experiment** (and hence implicitly designed it). **If it is not clear whether Option A or B is appropriate, use whichever option yields the highest score. The default is Option A.** **C:** The response is **blank, incomprehensible** or the response only **gives a conclusion.**
5	1	4	**A:** Response **describes a design** . **Then score as follows:** 1 pt: a reasonable part, or step, of running the experiment is mentioned, not including counting washers or repeating the steps across boards. There should be some explicit statement which cues this, such as "put boards at the edge of the table" or "string through hook on board" 1 pt: mentions putting/counting the number of washers on the hook. This may also be implicit, if the actual counts of washers are mentioned, or statements like "more than", "less than" and "in between" are used. 1 pt: mentions doing the same operations for <u>at least</u> <u>two</u> <u>boards</u>. 1 pt: mentions repeating the operations for <u>all three</u> <u>boards</u>. **B:** student **actually performed the experiment** . **Then score as follows:** 1 pt: something is said about procedures used. 1 pt: the number of washers on the hook are counted. 1 pt: repeats the operations for <u>at least</u> <u>two</u> <u>boards</u>. 1 pt: repeats the operations for <u>all three</u> <u>boards</u>. **C:** The response is **blank, incomprehensible** or only **gives a conclusion**. Zero points.
6	1	3	1 pt: Includes at least 2 boards. 1 pt: Provides a number of washers for each board. 1 pt: The number of washers increases as the surface roughness increases. Note that there was some variation in the equipment, so that some students will report findings that the felt was rougher than the sandpaper. These answers should be accepted. The <u>plain</u> board must have the <u>fewest</u> washers associated with it.

Rater Answer Form - Friction

Section I

Rater Name:________________________ Date: July __________, 1993

Rater ID Number:________________ Starting Time:_____:____AM/PM

Instructions: Circle the number of points awarded for each question.

Student ID Number	p4/Item 1	p4/Item 2	p4/Item 3	p5/Item 1		p6/Item 1
_____ - ______ - ______ - 31	0 1	0 1	0 1	A B C	0 1 2 3 4	0 1 2 3
_____ - ______ - ______ - 31	0 1	0 1	0 1	A B C	0 1 2 3 4	0 1 2 3
_____ - ______ - ______ - 31	0 1	0 1	0 1	A B C	0 1 2 3 4	0 1 2 3
_____ - ______ - ______ - 31	0 1	0 1	0 1	A B C	0 1 2 3 4	0 1 2 3
_____ - ______ - ______ - 31	0 1	0 1	0 1	A B C	0 1 2 3 4	0 1 2 3
_____ - ______ - ______ - 31	0 1	0 1	0 1	A B C	0 1 2 3 4	0 1 2 3
_____ - ______ - ______ - 31	0 1	0 1	0 1	A B C	0 1 2 3 4	0 1 2 3
_____ - ______ - ______ - 31	0 1	0 1	0 1	A B C	0 1 2 3 4	0 1 2 3
_____ - ______ - ______ - 31	0 1	0 1	0 1	A B C	0 1 2 3 4	0 1 2 3
_____ - ______ - ______ - 31	0 1	0 1	0 1	A B C	0 1 2 3 4	0 1 2 3
_____ - ______ - ______ - 31	0 1	0 1	0 1	A B C	0 1 2 3 4	0 1 2 3
_____ - ______ - ______ - 31	0 1	0 1	0 1	A B C	0 1 2 3 4	0 1 2 3
_____ - ______ - ______ - 31	0 1	0 1	0 1	A B C	0 1 2 3 4	0 1 2 3
_____ - ______ - ______ - 31	0 1	0 1	0 1	A B C	0 1 2 3 4	0 1 2 3
_____ - ______ - ______ - 31	0 1	0 1	0 1	A B C	0 1 2 3 4	0 1 2 3
_____ - ______ - ______ - 31	0 1	0 1	0 1	A B C	0 1 2 3 4	0 1 2 3
_____ - ______ - ______ - 31	0 1	0 1	0 1	A B C	0 1 2 3 4	0 1 2 3
_____ - ______ - ______ - 31	0 1	0 1	0 1	A B C	0 1 2 3 4	0 1 2 3
_____ - ______ - ______ - 31	0 1	0 1	0 1	A B C	0 1 2 3 4	0 1 2 3
_____ - ______ - ______ - 31	0 1	0 1	0 1	A B C	0 1 2 3 4	0 1 2 3

Scoring Guide - Friction

Section II

Page	Item	Possible Points	Scoring Criteria
3	1	4	1 pt: all the surface textures are represented on the horizontal axis. Numbers are not sufficient, unless they are linked with the table above. 1 pt: an equal interval scale is given for the force axis (may be increasing or decreasing) 1 pt: all the values from the table are plotted (the type of graph does not matter) 1 pt: all the values are represented correctly on the graph.
4	1	1	1 pt for a statement such as: force increased more washers pull harder
4	2	1	1 pt: Maria was right.
4	3	1	1 pt for a statement such as: Force increased (more washers) as surface texture became rougher If you look at each board, the answers are different and are increasing
5	1	3	1 pt: the reasoning recognizes differences in difficulty of rubbing 1 pt: the reasoning recognizes differences in the number of rubs (that there is an offset due the this difference) 1 pt: a logical inference is made - either in writing, or that relates to the circled answer above

Note: Graphs from the Incline task were used to illustrate the scoring criteria for graphs in the Friction task. For Friction the horizontal axis should be labeled "Surface Texture (Board)" and the levels should be "Plain," "Felt" and "Sandpaper" (in that order). The vertical axis is the same, but the values should be 8, 12 and 17 (in that order).

Note: Graphs from the Incline task were used to illustrate the scoring criteria for graphs in the Friction task. For Friction the horizontal axis should be labeled "Surface Texture (Board)" and the levels should be "Plain," "Felt" and "Sandpaper" (in that order). The vertical axis is the same, but the values should be 8, 12 and 17 (in that order).

Example 1

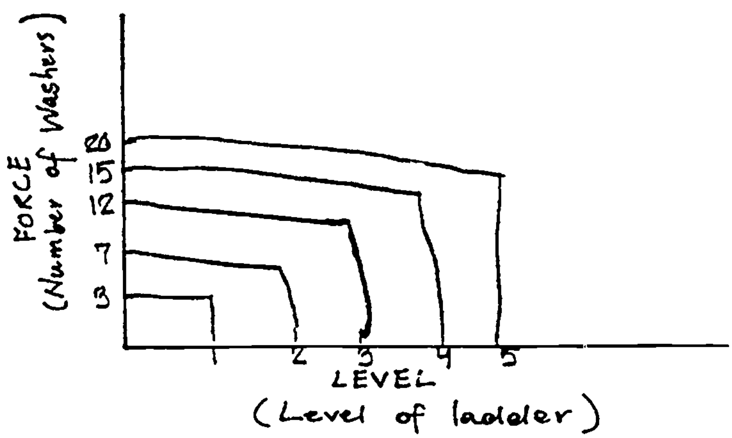
The following graph would receive a score of 2 points.

Point for....	Points Received
Horizontal Axis:	1
Vertical Axis:	0 (not clearly equal interval)
Plotting all the points:	1 -- for this point and the last point a combined total of 1 point is given because of the 90 degree lines in the graph.
Plotting the points correctly:	See above point
Total Points	2

Frank and Al wrote down their results in the table below.

LEVEL (Level of Ladder)	FORCE (Number of Washers)
1	3
2	7
3	12
4	15
5	20

Use the information from the table to graph the findings from Frank's and Al's experiment.



GO TO NEXT PAGE

Note: Graphs from the Incline task were used to illustrate the scoring criteria for graphs in the Friction task. For Friction the horizontal axis should be labeled "Surface Texture (Board)" and the levels should be "Plain," "Felt" and "Sandpaper" (in that order). The vertical axis is the same, but the values should be 8, 12 and 17 (in that order).

Example 2

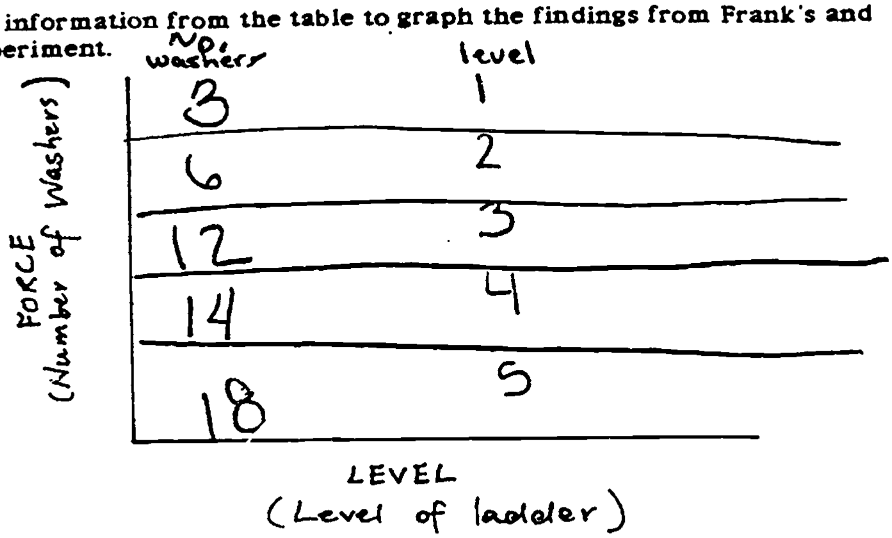
The following graph would receive a score of 0 points.

Point for....	Points Received
Horizontal Axis:	No graph, no points. (The chart merely is inverted and placed in the graph.)
Vertical Axis:	
Plotting all the points:	
Plotting the points correctly:	
Total Points	0

Frank and Al wrote down their results in the table below.

LEVEL (Level of Ladder)	FORCE (Number of Washers)
1	3
2	7
3	12
4	15
5	20

Use the information from the table to graph the findings from Frank's and Al's experiment.



GO TO NEXT PAGE

Note: Graphs from the Incline task were used to illustrate the scoring criteria for graphs in the Friction task. For Friction the horizontal axis should be labeled "Surface Texture (Board)" and the levels should be "Plain," "Felt" and "Sandpaper" (in that order). The vertical axis is the same, but the values should be 8, 12 and 17 (in that order).

Example 3

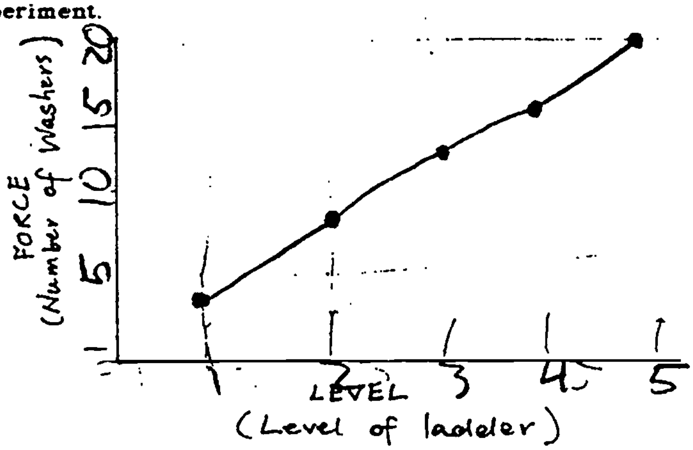
The following graph would receive a score of 4 points.

Point for....	Points Received
Horizontal Axis:	1
Vertical Axis:	1 (clearly equal interval)
Plotting all the points:	1 -- While 90 degrees lines are in the graph, there is a clear line graph
Plotting the points correctly:	1
Total Points	4

Frank and Al wrote down their results in the table below.

LEVEL (Level of Ladder)	FORCE (Number of Washers)
1	3
2	7
3	12
4	15
5	20

Use the information from the table to graph the findings from Frank's and Al's experiment.



GO TO NEXT PAGE

Note: Graphs from the Incline task were used to illustrate the scoring criteria for graphs in the Friction task. For Friction the horizontal axis should be labeled "Surface Texture (Board)" and the levels should be "Plain," "Felt" and "Sandpaper" (in that order). The vertical axis is the same, but the values should be 8, 12 and 17 (in that order).

Example 4

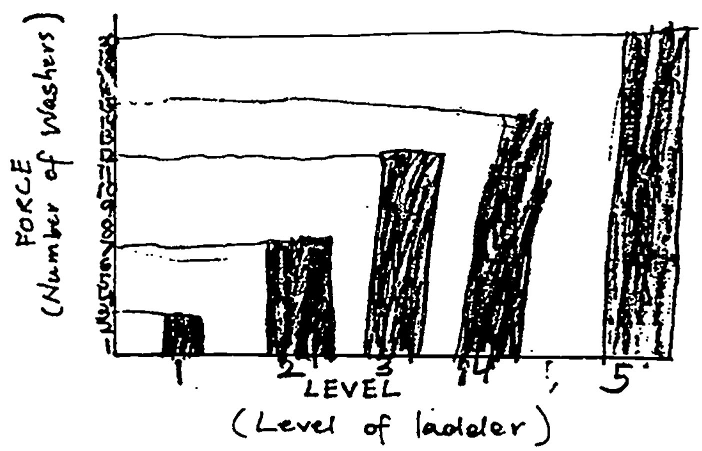
The following graph would receive a score of 4 points.

<u>Point for....</u>	<u>Points Received</u>
Horizontal Axis:	1
Vertical Axis:	1 (clearly equal interval)
Plotting all the points:	1 -- While 90 degrees lines are in the graph, there is a clear bar graph
Plotting the points correctly:	1
<u>Total Points</u>	4

Frank and Al wrote down their results in the table below.

LEVEL (Level of Ladder)	FORCE (Number of Washers)
1	3
2	7
3	12
4	15
5	20

Use the information from the table to graph the findings from Frank's and Al's experiment.



GO TO NEXT PAGE

Note: Graphs from the Incline task were used to illustrate the scoring criteria for graphs in the Friction task. For Friction the horizontal axis should be labeled "Surface Texture (Board)" and the levels should be "Plain," "Felt" and "Sandpaper" (in that order). The vertical axis is the same, but the values should be 8, 12 and 17 (in that order).

Example 5

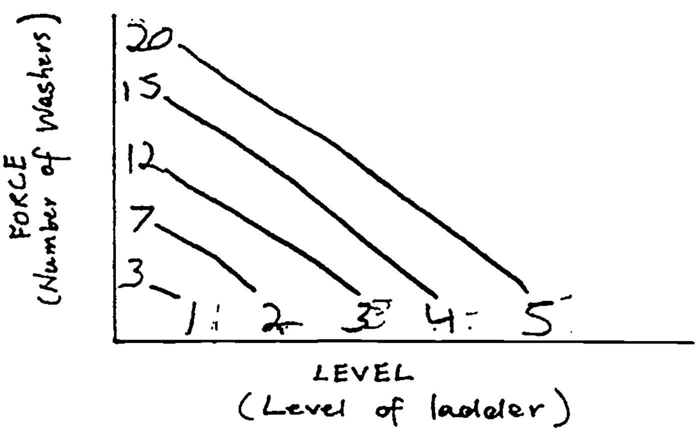
The following graph would receive a score of 1 point.

Point for....	Points Received
Horizontal Axis:	1
Vertical Axis:	0 (clearly not equal interval)
Plotting all the points:	0 -- there is no plot of a "graph point," even though there is a connection of the values on the horizontal and vertical axis
Plotting the points correctly:	0
Total Points	1

Frank and Al wrote down their results in the table below.

LEVEL (Level of Ladder)	FORCE (Number of Washers)
1	3
2	7
3	12
4	15
5	20

Use the information from the table to graph the findings from Frank's and Al's experiment.



GO TO NEXT PAGE

Rater Answer Form - Friction
Section II

Rater Name:________________________ Date: July __________, 1993

Rater ID Number:________________ Starting Time:_____:____AM/PM

Instructions: Circle the number of points awarded for each question.

Student ID Number	p3/Item 1	p4/Item 1	p4/Item 2	p4/Item 3	p5/Item 1
_____ - _____ - _____ - 32	0 1 2 3 4	0 1	0 1	0 1	0 1 2 3
_____ - _____ - _____ - 32	0 1 2 3 4	0 1	0 1	0 1	0 1 2 3
_____ - _____ - _____ - 32	0 1 2 3 4	0 1	0 1	0 1	0 1 2 3
_____ - _____ - _____ - 32	0 1 2 3 4	0 1	0 1	0 1	0 1 2 3
_____ - _____ - _____ - 32	0 1 2 3 4	0 1	0 1	0 1	0 1 2 3
_____ - _____ - _____ - 32	0 1 2 3 4	0 1	0 1	0 1	0 1 2 3
_____ - _____ - _____ - 32	0 1 2 3 4	0 1	0 1	0 1	0 1 2 3
_____ - _____ - _____ - 32	0 1 2 3 4	0 1	0 1	0 1	0 1 2 3
_____ - _____ - _____ - 32	0 1 2 3 4	0 1	0 1	0 1	0 1 2 3
_____ - _____ - _____ - 32	0 1 2 3 4	0 1	0 1	0 1	0 1 2 3
_____ - _____ - _____ - 32	0 1 2 3 4	0 1	0 1	0 1	0 1 2 3
_____ - _____ - _____ - 32	0 1 2 3 4	0 1	0 1	0 1	0 1 2 3
_____ - _____ - _____ - 32	0 1 2 3 4	0 1	0 1	0 1	0 1 2 3
_____ - _____ - _____ - 32	0 1 2 3 4	0 1	0 1	0 1	0 1 2 3
_____ - _____ - _____ - 32	0 1 2 3 4	0 1	0 1	0 1	0 1 2 3
_____ - _____ - _____ - 32	0 1 2 3 4	0 1	0 1	0 1	0 1 2 3
_____ - _____ - _____ - 32	0 1 2 3 4	0 1	0 1	0 1	0 1 2 3
_____ - _____ - _____ - 32	0 1 2 3 4	0 1	0 1	0 1	0 1 2 3
_____ - _____ - _____ - 32	0 1 2 3 4	0 1	0 1	0 1	0 1 2 3
_____ - _____ - _____ - 32	0 1 2 3 4	0 1	0 1	0 1	0 1 2 3

4. Pendulum

The pendulum was one of two Inference shell tasks from the domain of physics designed by RAND and administered to sixth-grade students in 1993. The Inference shell is written in narrative form.

In the pendulum task, a student is given two strings of different lengths, two weights with hooks permitting them to be attached to either string, a stopwatch, and a bar from which strings and weights can be suspended and swung. The student is instructed on how to suspend a weight from a string to create a pendulum and then on how to measure the periodicity of the pendulum by noting the time it takes to swing back and forth a fixed number of times. The student is instructed to repeat the experiment for all four combinations of strings and weights. Then the student is asked which influences the time more—the length of the string or the weight at the end of the pendulum. The student is also asked to justify the answer based on the experiment. Finally, the student is shown another pendulum with intermediate length string and weight and is asked to predict its behavior without testing it.

The components of the pendulum task will be found on the following pages:

Inference Shell

Students are presented with a situation in which they can measure/observe three variables, one outcome and two predictors. Both predictors are plausibly related to the outcome, but only one of the predictors is correlated with the outcome variable. The student is asked to measure the outcome variable under four conditions, defined by the four combinations of high and low values on each predictor. The student is shown how to make the necessary measurements for one condition (e.g., high on predictor A and low on predictor B) and record the results. The student is told to complete the experiment (make the measurements under the other conditions) and to determine which predictor affects the outcome. After collecting the relevant data, the student is asked to use the information gained from the experiment to identify which variable affects the outcome and then to predict the behavior of the outcome variable under different levels of the two predictors.

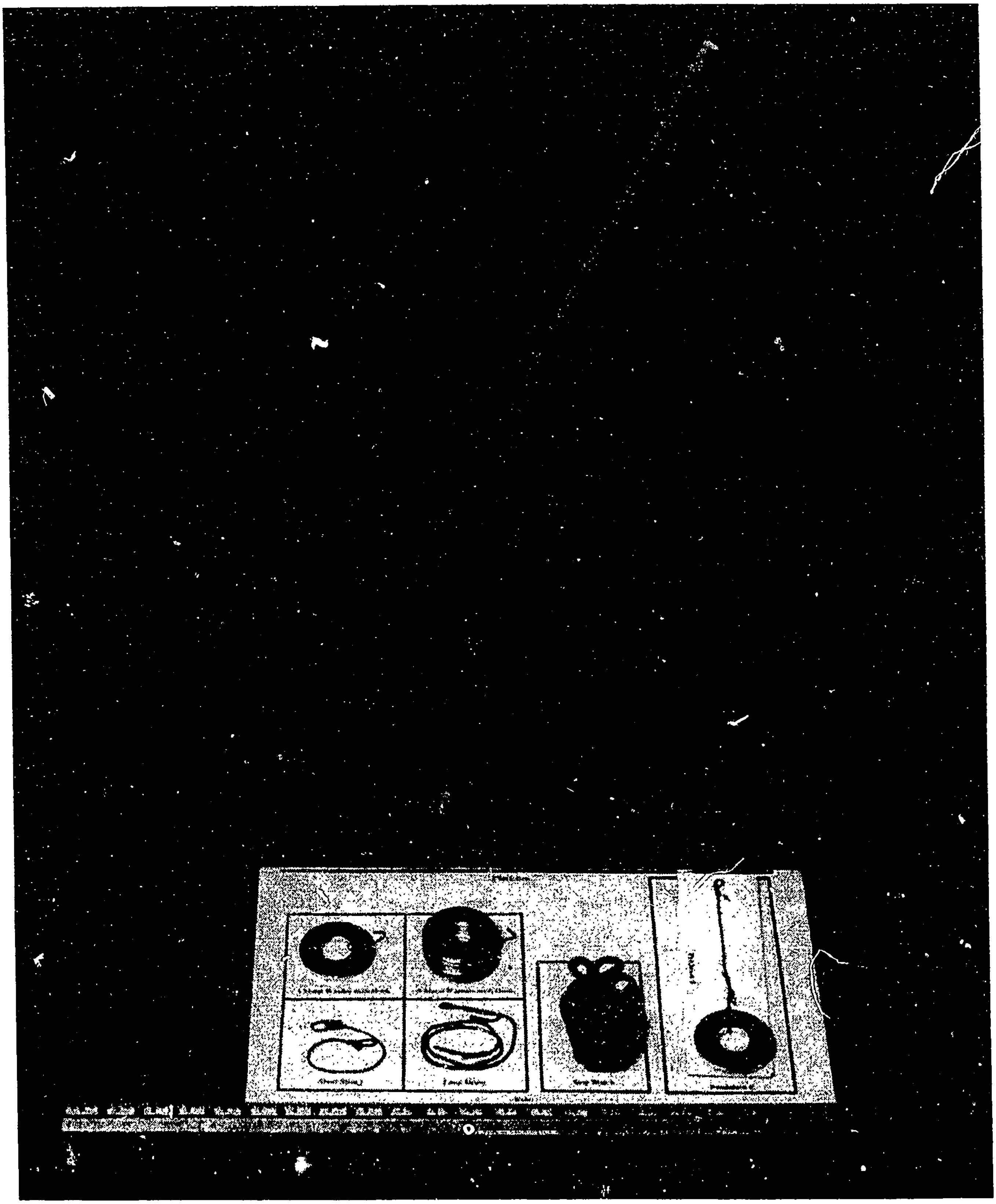


Figure 3—Equipment for Pendulum

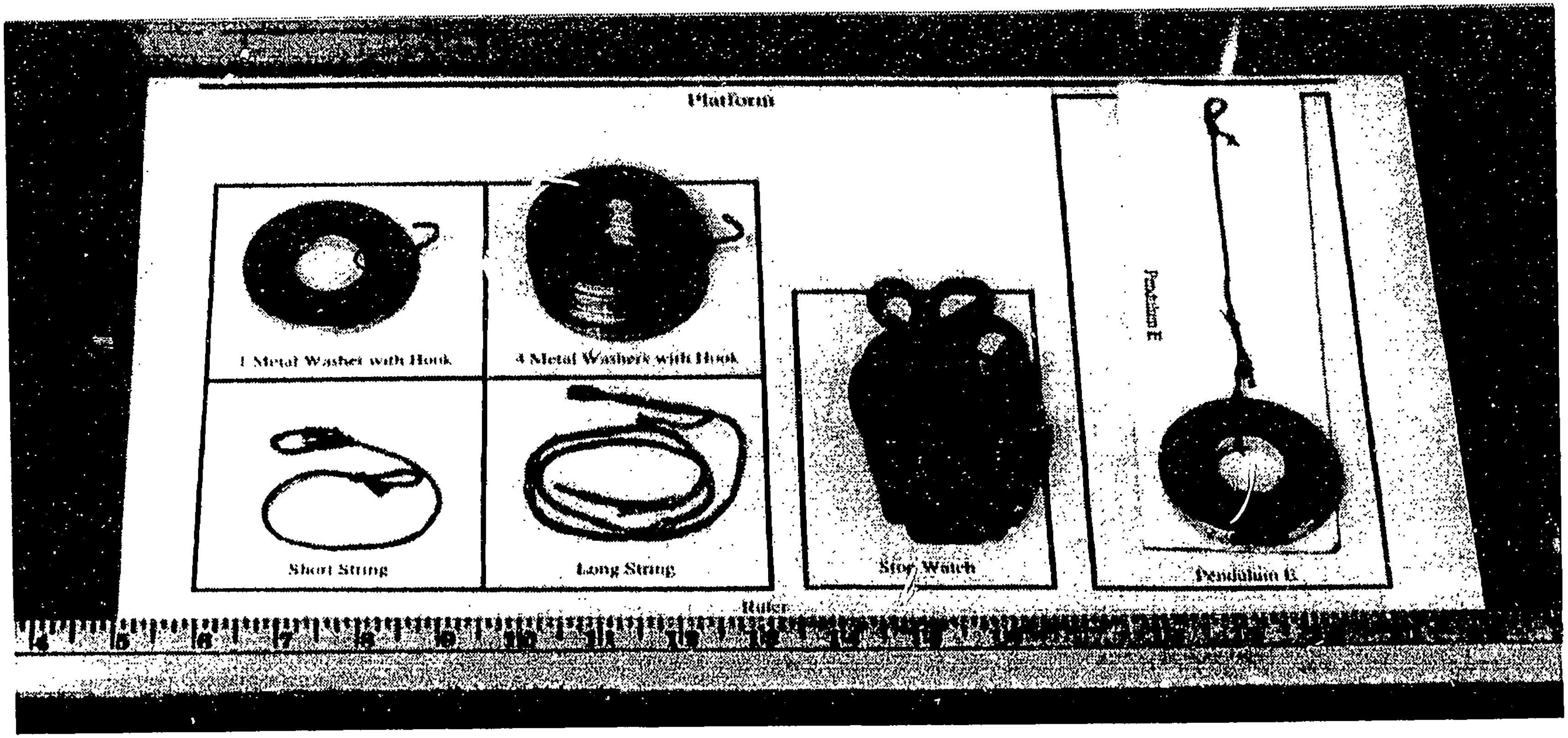


Figure 4—Equipment for Pendulum (Close Up)

Task page 1

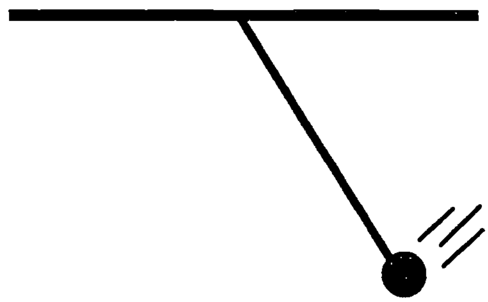
Name:____________________
First Last
Date: ____________________

Do not write in this box.
ID: ____________
SCH: ____________
CLS: ____________

Using a Pendulum

Please print your name and today's date on these instructions.

A ***pendulum*** is a piece of wood, metal, wire or other material that hangs from the top so it can move back and forth like a swing. Most pendulums have a weight at one end. Pendulums are often used to help large clocks keep time. Here is a picture of a pendulum.



Pendulums can swing at different speeds. Your job is to find out how the length and weight of a pendulum affect how fast it swings.

Materials: Look at the placemat in front of you, and raise your hand if you are missing any of these items:

Platform and stick with hook at end	Ruler
Long string	Stop Watch
Short string	Pencil
1 metal washer with hook	Pendulum E on cardboard
4 metal washers with hook	Data Sneet (on the back page of this booklet)

GO TO THE NEXT PAGE

Task page 2

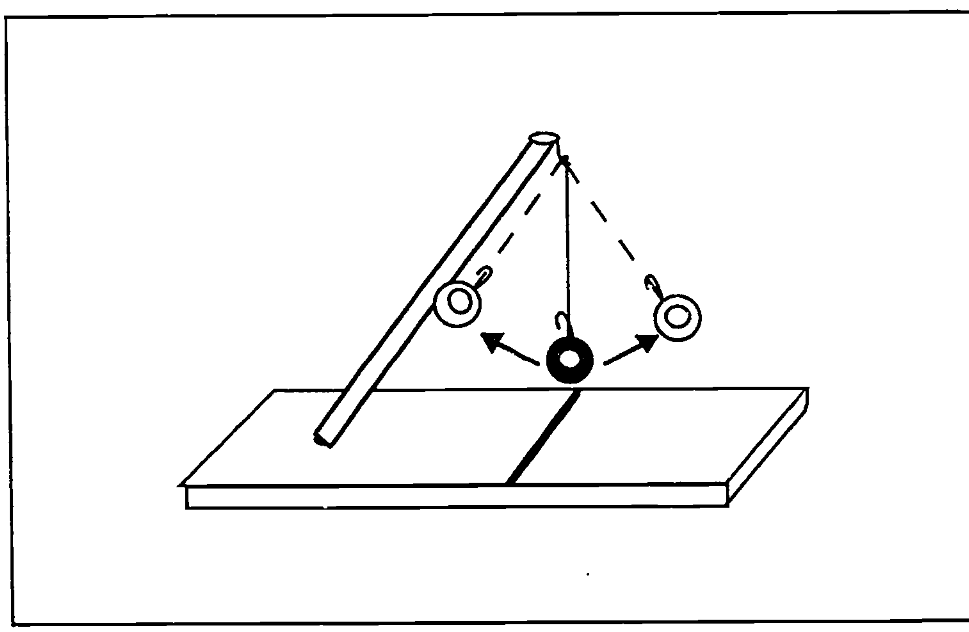
Step 1: Practice using the stopwatch.

How to operate the stopwatch:

(a) Push the LAP RESET button. This will reset the stopwatch to 0 seconds.
(b) Push the START STOP button. The stopwatch will start, and will continue until you stop it.
(c) Push the START STOP button again. The watch will stop and will show the amount of time that has passed since it was started.

Step 2: Make Pendulum A (short string, 1 washer).

a. Attach the short string to the hook at the top of the stick.
b. Attach 1 washer to the bottom of the string.
c. Pendulum A should look like this:



GO TO THE NEXT PAGE

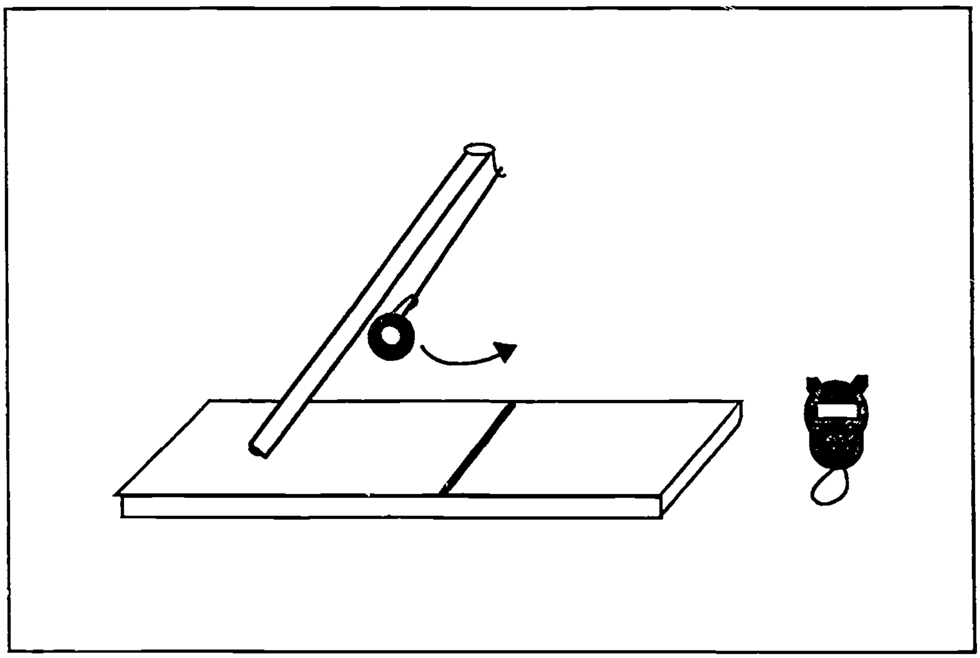
Task page 3

Step 3: Practice timing the speed of a pendulum.

The time it takes to swing back and forth across the line 20 times is one way to measure the speed of the pendulum. Look at the picture and follow these instructions.

a. Reset the stopwatch to zero.
b. With one hand, pull the washer to the side so it just touches the stick.
c. With the other hand hold the stopwatch.
d. At the same time, start the watch and release the washer.
d. Count the number of times the washer crosses the line on the platform.
e. When the washer has crossed the line 20 times, stop the watch.
f. Read the time from the stopwatch.

Raise your hand if you have any questions.



GO TO THE NEXT PAGE

Task page 4

Step 4: Measure the speed of Pendulum A.

Follow the directions in Step 3 to find the speed of Pendulum A.

How many seconds did it take the pendulum to swing across the center line 20 times?

Answer: _____ seconds

Step 5: Measure Pendulum A.

a. Use the ruler to measure the length of the string.

How many inches long is the string? Answer: ____ inches

b. Each washer weighs the same amount. The greater the number of washers the heavier the pendulum.

How many washers were used? Answer: ____ washer(s)

Step 6: Write the results for Pendulum A on your Data Sheet (on the back page of this booklet).

a. Write the time it took Pendulum A to swing 20 times under the words "number of seconds needed for 20 swings."
b. Write how many inches long the string was under the word "length."
c. Write the number of washers under the heading "number of washers."

Step 7: Measuring the speed of Pendulums B, C and D.

Here is a list of other pendulums you can make:

Pendulum B: short string with 4 washers
Pendulum C: long string with 1 washer
Pendulum D: long string with 4 washers

You need to make each pendulum and measure its speed. Repeat steps 4, 5 and 6 for pendulums B, C, and D. Record the time, the length of the string and the number of washers on your Data Sheet.

GO TO THE NEXT PAGE

Task page 5

Step 8: Describe and explain your results.

1. Which two pendulums took the most time to swing 20 times?

____

____

2. Dale says the weight of the pendulum has the biggest effect on how fast it swings. Pat says the length of the string is more important. Who is right? _____

Explain your answer.

____

____

____

____

3. Look at Pendulum E on the cardboard. How much time would it take Pendulum E to swing 20 times? (Circle one answer.)

a) **More** time than any of the other pendulums.
b) **Less** time than any of the other pendulums.
c) The **same** time as Pendulum A.
d) The **same** time as Penduium B.
e) **In between** the times of Pendulum A and Pendulum D.

Explain your answer.

____

____

____

____

GO TO THE NEXT PAGE

Task page 6

4. Do you think it was important to have the line drawn directly below the hook instead of closer to the base of the stick? (Check one answer.)

Yes _____ No _____ I'm not sure _____

Explain your answer.

____

____

____

____

STOP

Task page 7

BLANK PAGE

Task page 8

Data Sheet

PENDULUM	NUMBER OF SECONDS NEEDED FOR 20 SWINGS	LENGTH (inches)	NUMBER OF WASHERS
A			
B			
C			
D			

Scoring Guide - Using a Pendulum

<table>
<tr><th>Page</th><th>Item</th><th>Possible Points</th><th>Scoring Criteria</th></tr>
<tr><td>8</td><td>Data Sheet</td><td>4</td><td>1 pt: each pendulum measured correctly. Answer must include seconds, length and number of washers to earn a point. However, answer does not have to have the correct label (letter). Acceptable values:
<table>
<tr><th>Pendulum</th><th>Seconds</th><th>Length</th><th>Washers</th></tr>
<tr><td>A</td><td>9-11 or 18-22</td><td>7.5-9</td><td>1</td></tr>
<tr><td>B</td><td>9-11 or 18-22</td><td>7.5-9</td><td>4</td></tr>
<tr><td>C</td><td>13-15 or 26-30</td><td>8-19.5</td><td>1</td></tr>
<tr><td>D</td><td>13-15 or 26-30</td><td>18-19.5</td><td>4</td></tr>
</table>
For seconds use either the left-hand range or the right-hand range, but not both. Pick whichever side gives the student the most points.
Use the letters of the two pendulums that took the most time to swing for scoring page 5, item 1.</td></tr>
<tr><td>5</td><td>1</td><td>2</td><td>1 pt each: for selecting or describing the two pendulums that took the longest time. Normally these will be C and D. If the student has labeled the pendulum differently, then award points based on their labels for each long-string pendulum they select. The pendulums they indicate must be the ones with long strings. If they timed the short strings wrong they do not get a point for selected them.
Give one point if one answer is correct and the other is wrong.
If the data table is empty, award points anyway for indicating C and D.
Do not penalize the student for data that are out of range (e.g., length 6 inches) if the data table is consistent with the experiment (i.e., the two short strings with 1 and 4 washers take less time than the two long strings)
If the data table is jumbled (i.e., is not consistent) do not give the benefit of the doubt to students who pick C and D; only award points for picking pendulum that took longer to swing.</td></tr>
</table>

Scoring Guide - Using a Pendulum

Page	Item	Possible Points	Scoring Criteria
5	2a	1	1 pt: Pat is correct. If blank, check in 2b to see if answer is there. Award a point for "length" or other phrase that was part of what Pat actually argued.
5	2b	2	1 pt: saying the length of the string is important, e.g., the long string swings slower, etc. 1 pt: saying the number of washers is not important **OR all of the following:** (a) saying the number of washers is important (b) this statement is supported by the data table (c) saying it is less important than the length of the string. Note: two points can be awarded for a response that just compares two pendulums if it describes the roles of both length and weight (e.g., long string with 4 washers was slower than short string with 4 washers)
5	3a	1	1 pt: choice B (less time than any other pendulum).
5	3b	2	1 pt: saying the string in E is the shortest. "Short string" is not acceptable. Use response to 3a to determine meaning of "shorter." If the student chose B then describing the string as "shorter" is acceptable. If the student chose an in-between answer, then "shorter" may not be acceptable if it implies shorter than one but not necessarily shorter than the other. 1 pt: saying the number of washers in E is not important **OR all of the following:** (a) saying the number of washers in E is important, (b) this statement is supported by the data table (c) saying it is less important than the length of the string.
6	4	2	1 pt: Yes 1 pt: if the line is not at the center, the pendulum can be swinging and not cross the line (e.g., "if you put it too close the washer might not reach all the way," "that's where it will cross the most," etc.) Do not give a point for "it wouldn't be even" or for comments about the time not being the same.

Rater Answer Form -- Using a Pendulum

Rater Name: ______________________ Date: July ____, 1993
Rater ID Number: ______ (RAND use only) Starting Time: ___ : ___ AM/PM

Instructions: Circle the number of points awarded for each question.

Student ID Number	Data Sheet	Item 1	Item 2a	Item 2b	Item 3a	Item 3b	Item 4
___ - ___ - _____ - 44	0 1 2 3 4	0 1 2	0 1	0 1 2	0 1	0 1 2	0 1 2
___ - ___ - _____ - 44	0 1 2 3 4	0 1 2	0 1	0 1 2	0 1	0 1 2	0 1 2
___ - ___ - _____ - 44	0 1 2 3 4	0 1 2	0 1	0 1 2	0 1	0 1 2	0 1 2
___ - ___ - _____ - 44	0 1 2 3 4	0 1 2	0 1	0 1 2	0 1	0 1 2	0 1 2
___ - ___ - _____ - 44	0 1 2 3 4	0 1 2	0 1	0 1 2	0 1	0 1 2	0 1 2
___ - ___ - _____ - 44	0 1 2 3 4	0 1 2	0 1	0 1 2	0 1	0 1 2	0 1 2
___ - ___ - _____ - 44	0 1 2 3 4	0 1 2	0 1	0 1 2	0 1	0 1 2	0 1 2
___ - ___ - _____ - 44	0 1 2 3 4	0 1 2	0 1	0 1 2	0 1	0 1 2	0 1 2
___ - ___ - _____ - 44	0 1 2 3 4	0 1 2	0 1	0 1 2	0 1	0 1 2	0 1 2
___ - ___ - _____ - 44	0 1 2 3 4	0 1 2	0 1	0 1 2	0 1	0 1 2	0 1 2
___ - ___ - _____ - 44	0 1 2 3 4	0 1 2	0 1	0 1 2	0 1	0 1 2	0 1 2
___ - ___ - _____ - 44	0 1 2 3 4	0 1 2	0 1	0 1 2	0 1	0 1 2	0 1 2
___ - ___ - _____ - 44	0 1 2 3 4	0 1 2	0 1	0 1 2	0 1	0 1 2	0 1 2
___ - ___ - _____ - 44	0 1 2 3 4	0 1 2	0 1	0 1 2	0 1	0 1 2	0 1 2
___ - ___ - _____ - 44	0 1 2 3 4	0 1 2	0 1	0 1 2	0 1	0 1 2	0 1 2
___ - ___ - _____ - 44	0 1 2 3 4	0 1 2	0 1	0 1 2	0 1	0 1 2	0 1 2
___ - ___ - _____ - 44	0 1 2 3 4	0 1 2	0 1	0 1 2	0 1	0 1 2	0 1 2
___ - ___ - _____ - 44	0 1 2 3 4	0 1 2	0 1	0 1 2	0 1	0 1 2	0 1 2
___ - ___ - _____ - 44	0 1 2 3 4	0 1 2	0 1	0 1 2	0 1	0 1 2	0 1 2
___ - ___ - _____ - 44	0 1 2 3 4	0 1 2	0 1	0 1 2	0 1	0 1 2	0 1 2

5. Lever

The lever task was one of two Inference shell tasks from the domain of physics designed by RAND. It was administered to sixth-grade students in 1993 and to eighth-grade students in 1994. The shell used for designing the task is identical to that for the pendulum task (see Section 4).

In the lever task, the student is asked to determine whether the number of washers required to lift a fixed weight is influenced more by the length of the lever or by the proportion of the bar on the side of the fulcrum where the weights are placed. To conduct this experiment the student is given four bars (two short and two long) with pivot notches either one-half or one-quarter of the way down the bar. The student is shown how to place the bar on the fulcrum, attach the weight to one end, and test the lever by adding washers to the other end until the weight rises off the table. The student is instructed to repeat the experiment for all four combinations of length and pivot point. Then the student is asked which influences the weight more—the length of the bar or the fraction of the bar on either side of the fulcrum. The student also is asked to justify the answer based on the experiment. Finally, the student is shown another lever with intermediate length and pivot point and is asked to predict its behavior without testing it.

The components of the lever task will be found on the following pages:

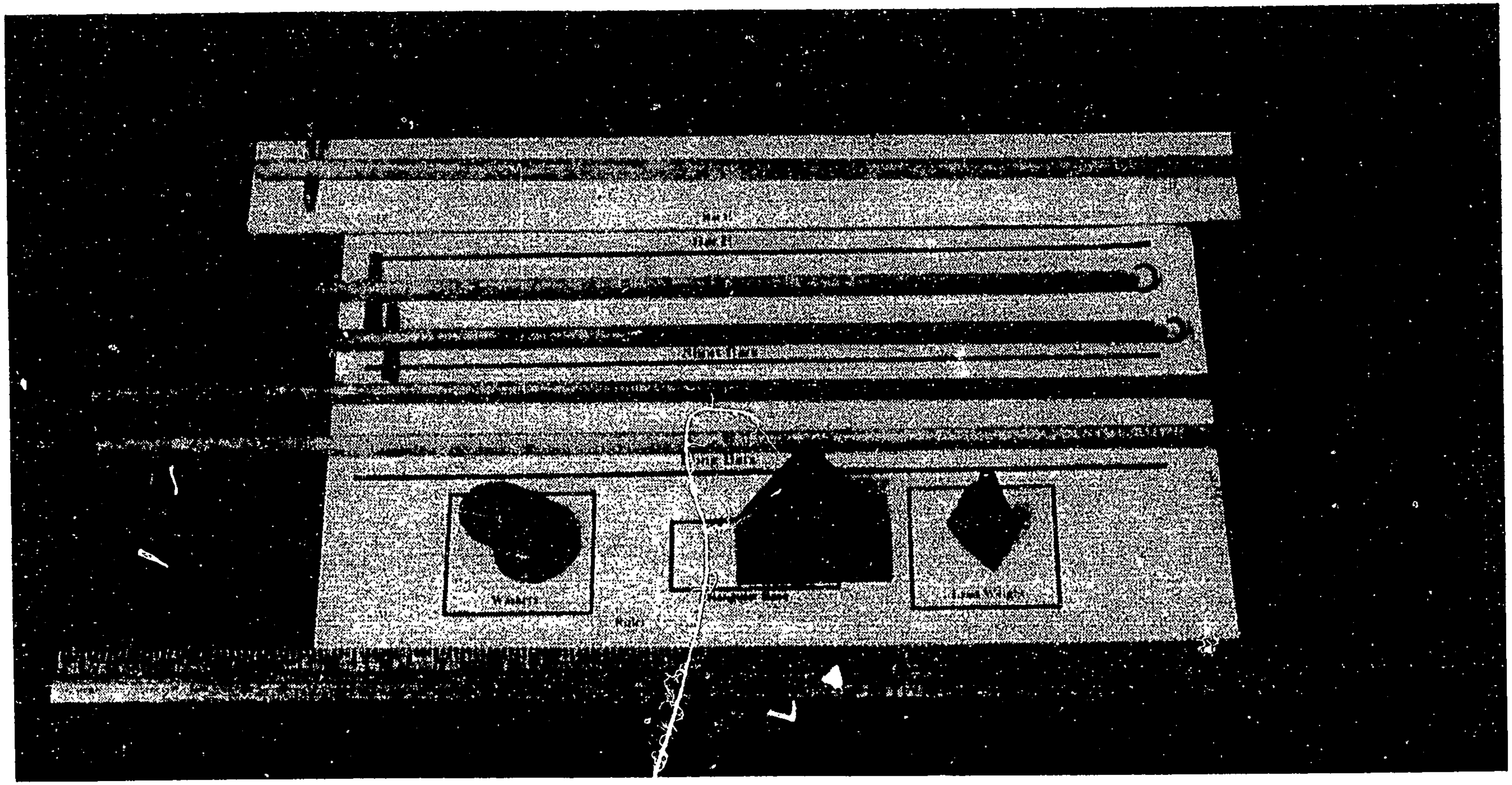


Figure 5—Equipment for Lever

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Task page 1

Name: ______________________
First Last

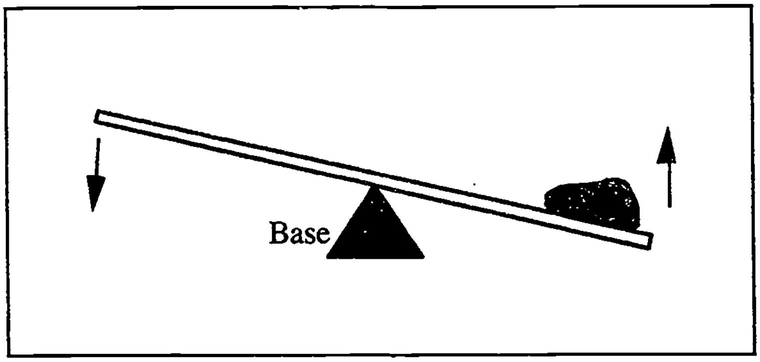
Date: ______________________

Do not write in this box.
ID:
SCH:
CLS:

Using a Lever

Please print your name and today's date on these instructions.

A ***lever*** is a solid bar that pivots at one point, like a see-saw or teeter-totter. Pushing down at one end makes the other end go up. Levers are often used to lift heavy objects. Here is a picture of a lever.



A lever can be any length . Where the lever touches the base is called the "pivot point." Your job is to find out how the length of the bar and the location of the pivot point affect how much a lever can lift.

Materials: Look at the placemat in front of you, and raise your hand if you are missing any of these items:	
Triangular Base	10 Washers
2 long bars	Ruler
2 short bars	Pencil
Lead weight	Data Sheet (on the back page of this booklet)
Bar E on cardboard	

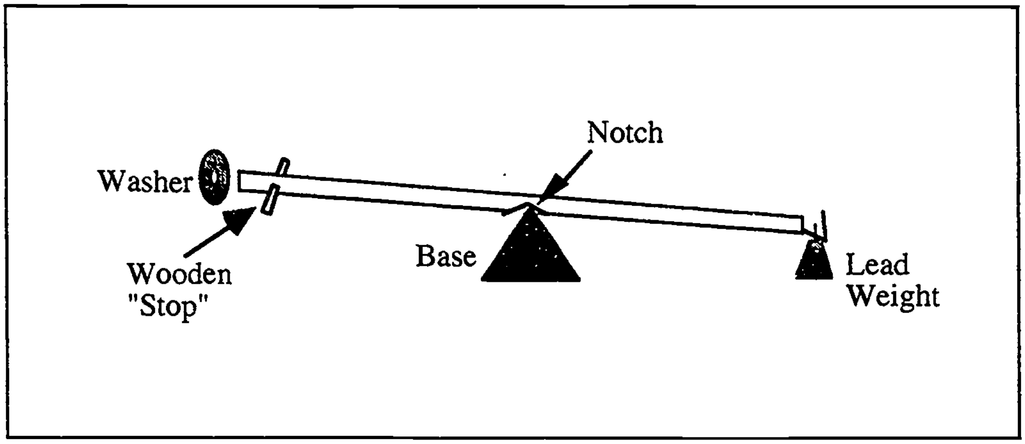
GO TO THE NEXT PAGE

Task page 2

Step 1: Make Lever A.

a. Pick up the long bar with the notch in the <u>middle</u>.
b. Attach the lead weight to the end of the bar with the hook.
c. Lay the bar across the stand so the notch rests on the top of the base.

Lever A should look like this.



Step 2: Test the lifting ability of Lever A.

a. Add washers to the other end of Lever A, one by one, until the lead weight first lifts and stays off the table.

How many washers did it take to lift the weight using Lever A?

Answer: ______ washers

GO TO THE NEXT PAGE

Task page 3

Step 3: Measure Lever A.

a. Use the ruler to measure the total length of the bar (from end to end).

How many inches long is the bar? Answer: ____ inches

b. Use the ruler to measure the length from the end with the hook to the notch.

How many inches is it from the end with the hook to the notch?

Answer: _____ inches

What fraction of the total length of the bar is between the end with the hook and the notch (one-half or one-quarter)?

Answer: _________ of the bar

Step 4: Write the results for Lever A on your Data Sheet (on the back page of this booklet).

a. Write the number of washers it took to lift the weight under the words "number of washers to lift weight."
b. Write the length of the bar under the words "total length of bar."
c. Write the fraction of the bar between the end with the hook and the notch under the words "fraction of bar lifting block."

Step 5: Test and measure Levers B, C and D.

Here is a list of the other levers you can make:

Lever B:	long bar with notch near the end with the hook
Lever C:	short bar with notch in the middle
Lever D:	short bar with notch near the end with the hook

Make each lever, test its lifting ability and measure its length. Repeat steps 2, 3 and 4 for each lever and record the results on your Data Sheet.

GO TO THE NEXT PAGE

Task page 4

Step 6: Describe and explain your results.

1. Which two levers needed the most washers to lift the weight?

____

____

2. Chris says the length of a bar has the biggest effect on its ability to lift objects. Jody says the location of the notch is more important. Who is right? ________

Explain your answer.

____

____

____

____

3. Look at Bar E on the cardboard. How many washers will it take to lift the weight with this bar? (Circle one answer.)

   a) **More** than any of the other levers.
   b) **Fewer** than any of the other levers.
   c) The **same** number as Lever B.
   d) The **same** number as Lever D.
   e) **In between** the numbers needed for Lever A and Lever D.

Explain your answer.

____

____

____

____

GO TO THE NEXT PAGE

Task page 5

4. The wooden "stop" is near one end of the bar. Do you think it is important that the distance between this end and the wooden "stop" is the same on all the levers? (Check one answer.)

Yes _____ No _______ I'm not sure _____

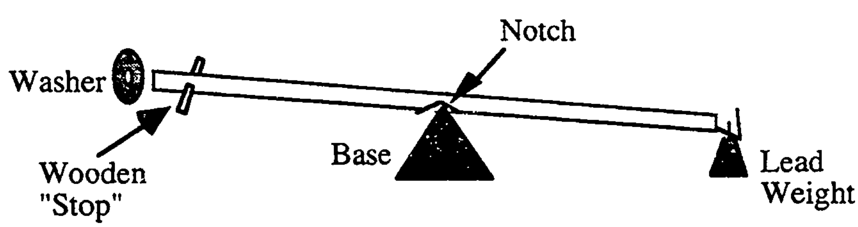
Explain your answer.

____

____

____

____



STOP

Task page 6

BLANK PAGE

Task page 8

Data Sheet

LEVER	NUMBER OF WASHERS TO LIFT WEIGHT	TOTAL LENGTH OF BAR	FRACTION OF BAR LIFTING WEIGHT (one-half, one-quarter)
A			
B			
C			
D			

Scoring Guide - Using a Lever

<table>
<tr><th>Page</th><th>Item</th><th>Possible Points</th><th>Scoring Criteria</th></tr>
<tr><td>8</td><td>Data Sheet</td><td>4</td><td>1 pt. for each lever measured correctly. Answer must include number of washers, length and fraction to earn a point. However, answer does not have to have the correct letter. Acceptable values:

<table>
<tr><th>Lever</th><th>Washers</th><th>Length</th><th>Fraction*</th></tr>
<tr><td>A</td><td>8-10</td><td>24-25</td><td>1/2</td></tr>
<tr><td>B</td><td>3-4</td><td>24-25</td><td>1/4</td></tr>
<tr><td>C</td><td>8-10</td><td>16-17</td><td>1/2</td></tr>
<tr><td>D</td><td>3-4</td><td>16-17</td><td>1/4</td></tr>
</table>
* or equivalent fraction, e.g., 12/24, 6/24, 2/4, etc. Must put entire fraction; may be off by fractions of an inch, e.g. 12 1/4 / 24.

• Do not accept 3/4 in place of 1/4.
• Use the letters of two levers with fractions equal to 1/2 (notches halfway) for scoring page 4, item 1.</td></tr>
<tr><td>4</td><td>1</td><td>2</td><td>1 pt. each: for selecting or describing the two levers with the notch 1/2 way. Normally this will be A and C.
• If the student has labeled the levers differently, then award points based on their labels for each lever they select that has the notch one-half way.
• Give one point if one answer is correct and the other is wrong.
• If the data table is empty, award points anyway for indicating A and C.
• Do not penalize the student on this question for data that are out of range (e.g., length 23 inches) if the data table is consistent with the experiment (i.e., the two levers with notch at 1/2 require more washers than the two with notches at 1/4).
• If the data table is jumbled (i.e., not consistent) do not give the benefit of the doubt to students who pick A and C.
• Do not give points for selecting levers that are not consistent with the correct results (they do not have to be exactly in range but all three parts must be discernible).
• Only award points for picking levers with the notch one-half way.</td></tr>
</table>

Scoring Guide - Using a Lever

Page	Item	Possible Points	Scoring Criteria
4	2a	1	1 pt.: Jody is correct. No points for "both" unless 2 points for 2b. • If blank, check 2b to see if answer is there, look for key words or phrases that were part of Jody's argument, e.g., "location" or "notch".
4	2b	1 . 2	1 pt.: saying that the bars with the notch nearer the hook (or "off center," or nearer the end") lifted with fewer washers (or "were better") [than the bars with the notches in the middle. - optional] • The weight of the bar is relevant, but discussing only the weight of the bar should not be awarded a point. • Not acceptable: Repeating Jody's statement, e.g., "the location of the notch is more important." 1 pt.: saying the length of the bar is not important; or the answer is the same for long or short bars - must mention both bars; **OR all of the following**: (a) saying the length of the bar is important, (b) this statement is supported by the data table (short bar with notch in the middle needed one more washer than the long bar with the notch in the middle), (c) saying it is less important than the location of the notch.
4	3a	1	1 pt.: choice B (fewer than any of the other levers). No points for 2 answers. If blank check to see if in 3b.
4	3b	2	1 pt.: saying the notch in E is closest to the hook/weight or farthest from the washers. • Do not give a point for "closer" or "farther" or "nearer the end" unless answer "b" is selected in 3a. • No points for "near the end," "close to the end." 1 pt.: saying the length of the bar in E is not important **OR all of the following**: (a) saying the length of the bar or the weight of the bar in E is important, (b) this statement is supported by the data table, (c) saying it is less important than the location of the notch.

Scoring Guide - Using a Lever

Page	Item	Possible Points	Scoring Criteria
5	4	2	1 pt.: Yes 1 pt.: so conditions would be similar (length of bars would be different) or the location of the washers affects the lifting power, e.g., "the weight would be in a different place" or more/less washers would be needed to lift the weight. • Do not award points for saying that the number of washers that could fit on the bar would be different or there wouldn't be enough room to hold the washers. • Do not award points for saying the washers would slide down the bar. • Do not award points for saying things about the base.

Rater Answer Form -- Using a Lever

Rater Name: ______________________ Date: July ___ , 1993
Rater ID Number: _____ (RAND use only) Starting Time: ___ : ___ AM/PM

Instructions: Circle the number of points awarded for each question.

Student ID Number	Data Sheet	Item 1	Item 2a	Item 2b	Item 3a	Item 3b	Item 4
___ - ___ - _____ - 43	0 1 2 3 4	0 1 2	0 1	0 1 2	0 1	0 1 2	0 1 2
___ - ___ - _____ - 43	0 1 2 3 4	0 1 2	0 1	0 1 2	0 1	0 1 2	0 1 2
___ - ___ - _____ - 43	0 1 2 3 4	0 1 2	0 1	0 1 2	0 1	0 1 2	0 1 2
___ - ___ - _____ - 43	0 1 2 3 4	0 1 2	0 1	0 1 2	0 1	0 1 2	0 1 2
___ - ___ - _____ - 43	0 1 2 3 4	0 1 2	0 1	0 1 2	0 1	0 1 2	0 1 2
___ - ___ - _____ - 43	0 1 2 3 4	0 1 2	0 1	0 1 2	0 1	0 1 2	0 1 2
___ - ___ - _____ - 43	0 1 2 3 4	0 1 2	0 1	0 1 2	0 1	0 1 2	0 1 2
___ - ___ - _____ - 43	0 1 2 3 4	0 1 2	0 1	0 1 2	0 1	0 1 2	0 1 2
___ - ___ - _____ - 43	0 1 2 3 4	0 1 2	0 1	0 1 2	0 1	0 1 2	0 1 2
___ - ___ - _____ - 43	0 1 2 3 4	0 1 2	0 1	0 1 2	0 1	0 1 2	0 1 2
___ - ___ - _____ - 43	0 1 2 3 4	0 1 2	0 1	0 1 2	0 1	0 1 2	0 1 2
___ - ___ - _____ - 43	0 1 2 3 4	0 1 2	0 1	0 1 2	0 1	0 1 2	0 1 2
___ - ___ - _____ - 43	0 1 2 3 4	0 1 2	0 1	0 1 2	0 1	0 1 2	0 1 2
___ - ___ - _____ - 43	0 1 2 3 4	0 1 2	0 1	0 1 2	0 1	0 1 2	0 1 2
___ - ___ - _____ - 43	0 1 2 3 4	0 1 2	0 1	0 1 2	0 1	0 1 2	0 1 2
___ - ___ - _____ - 43	0 1 2 3 4	0 1 2	0 1	0 1 2	0 1	0 1 2	0 1 2
___ - ___ - _____ - 43	0 1 2 3 4	0 1 2	0 1	0 1 2	0 1	0 1 2	0 1 2
___ - ___ - _____ - 43	0 1 2 3 4	0 1 2	0 1	0 1 2	0 1	0 1 2	0 1 2
___ - ___ - _____ - 43	0 1 2 3 4	0 1 2	0 1	0 1 2	0 1	0 1 2	0 1 2
___ - ___ - _____ - 43	0 1 2 3 4	0 1 2	0 1	0 1 2	0 1	0 1 2	0 1 2

6. Classification of Animals

The animals classification task was designed by RAND and administered to sixth-grade students in 1993. The Classification shell is written in narrative form.

Two tasks were developed from this shell. In the tasks, two-way classification is explained using pictures of people who differ in terms of age (old and young), position (sitting or standing), gender (male or female), and type of clothing (summer or winter). Students are shown how to classify the pictures into four mutually exclusive groups using two dimensions simultaneously (e.g., young-males, old-males, young-women, and old-women). This activity is the same in both tasks. In the animals classification task, students are given a set of plastic land and sea animals, and they are asked to create a two-way classification system. Then they are given a new animal, an amphibian, and are asked where it fit in their system and why. The second task (see Section 7) involves materials.

The components of the animals task will be found on the following pages:

Classification Shell

Students learn about two-way cross-classification using simple objects. They perform a simple "tuning" task in which they are led through the development of a two-way classification system, and they sort objects into four mutually exclusive groups. Then they are given a new set of objects that differ in a number of ways and they are asked to construct their own two-way classification system. Using any relevant features of the objects as the classification dimensions, they sort the objects appropriately. The only restrictions are that each object has to be put into one of the four cells and each cell has to have at least one object in it. Finally, students are given an additional object that has been concealed. They are asked to classify it using their system or to explain why it does not fit.

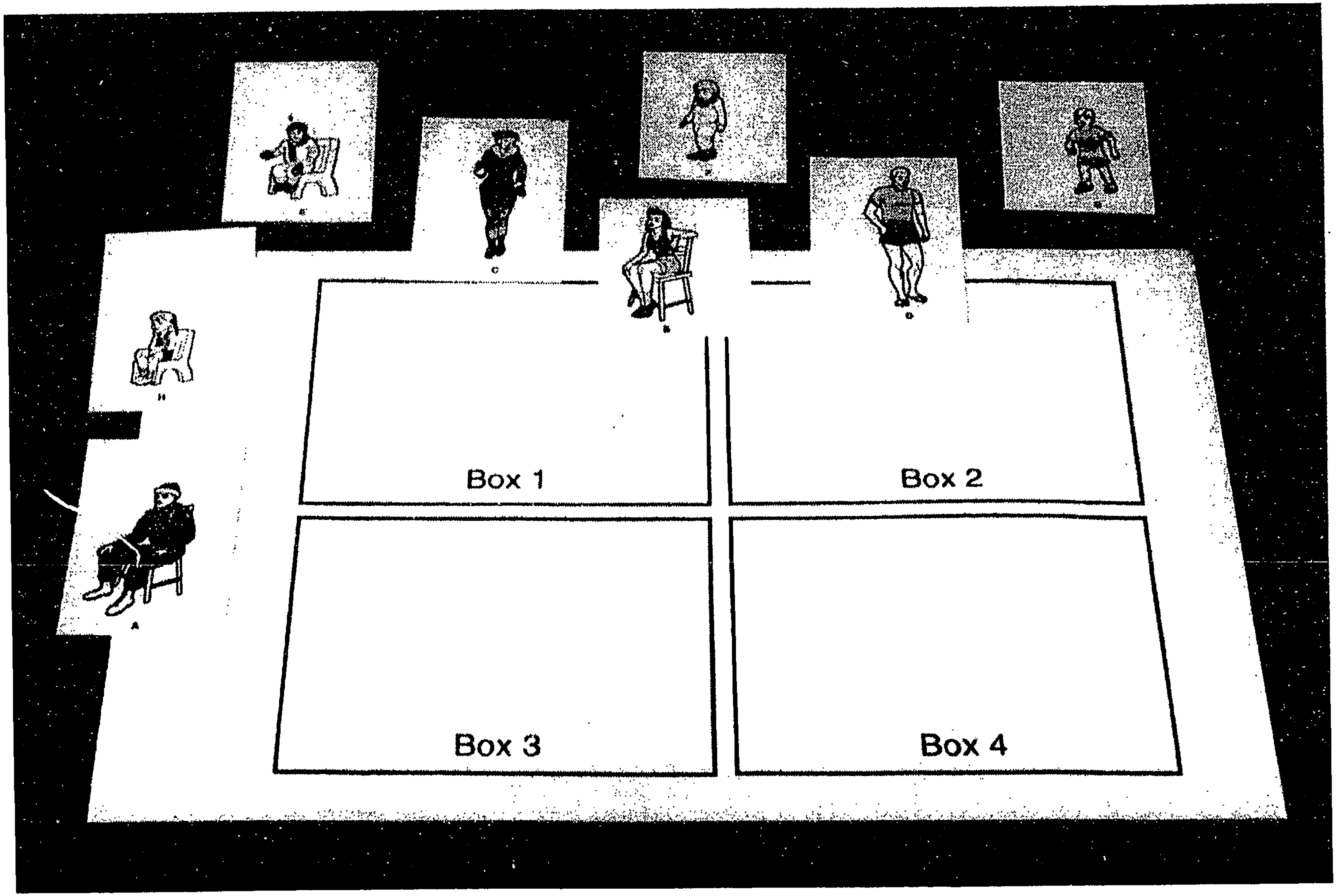


Figure 6—Equipment for Classification of Animals (Tuning Task)

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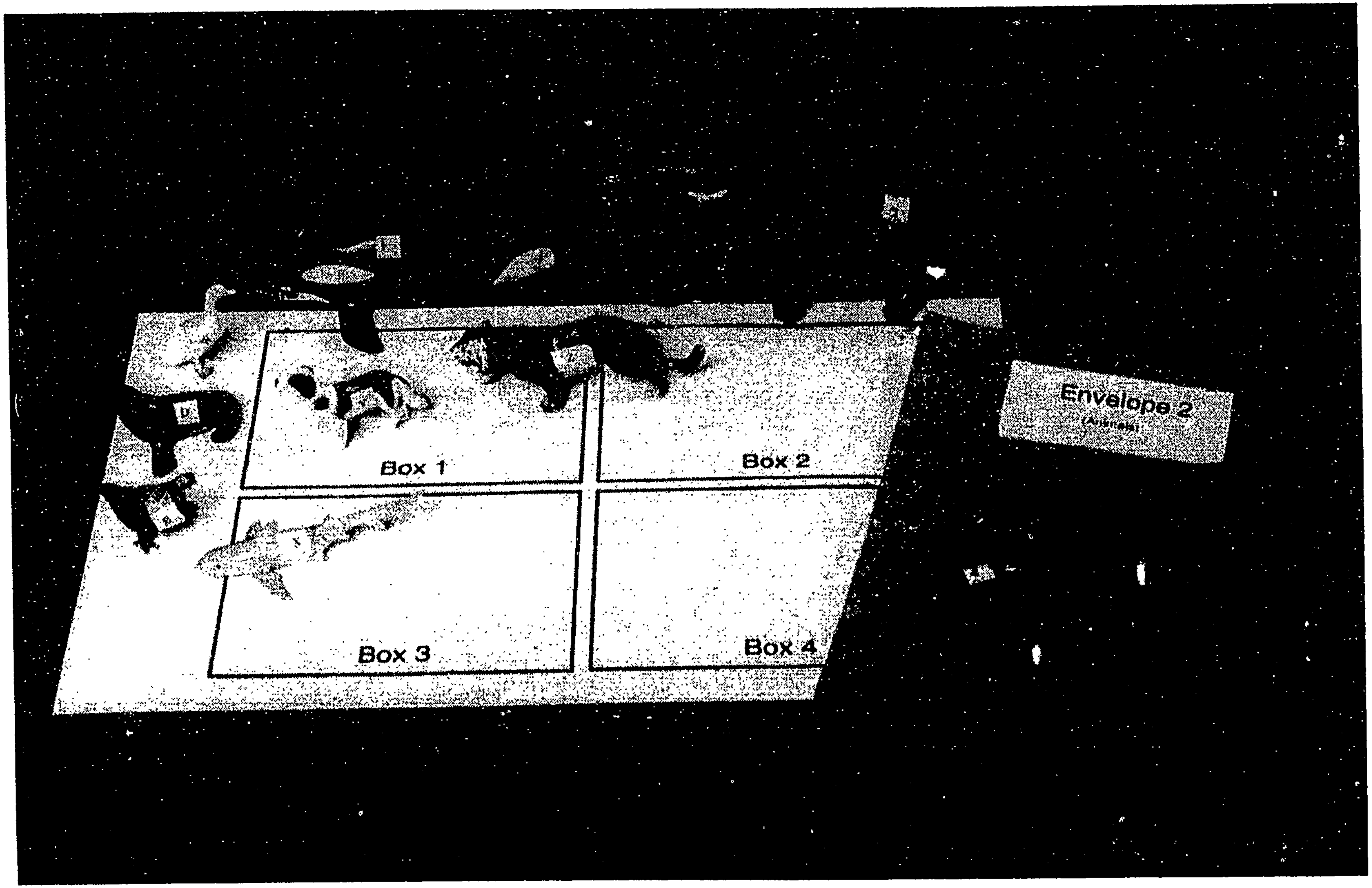

Figure 7—Equipment for Classification of Animals

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Task page 1

Name: ______________________
First Last
Date: ______________________

Do not write in this box:
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SCH:
CLS:

Classification

Part 1: Sorting People

The ways in which objects differ are called properties. Properties can be used to sort objects into groups. Color is one property you could use to classify cars. You might sort cars into two groups based on their color: blue and not blue. Another car property is speed. There could be two speed groups: fast and slow. You also could classify cars by how many doors they have. One group has 2 doors, another group has 4 doors, and so on. There are many different properties you could use to classify things.

1. Take the pictures out of the envelope labeled **"People"**.

2. Look at pictures **A** and **B**. List two ways the people in **A** and **B** are similar to each other:

   ____

   ____

3. List one way **A** is different from **B**:

   ____

4. Gender is one property. Every person is either male or female. Gender could be used to sort people into two groups; one group is males and the other is females.

   Do **A** and **B** belong to the same gender group? (Circle one answer)

   Yes No

5. Another property is body position. You can use this property to divide people into two groups: sitting and standing.

   Do **A** and **B** belong to the same body position group? (Circle one answer)

   Yes No

GO TO THE NEXT PAGE

Task page 2

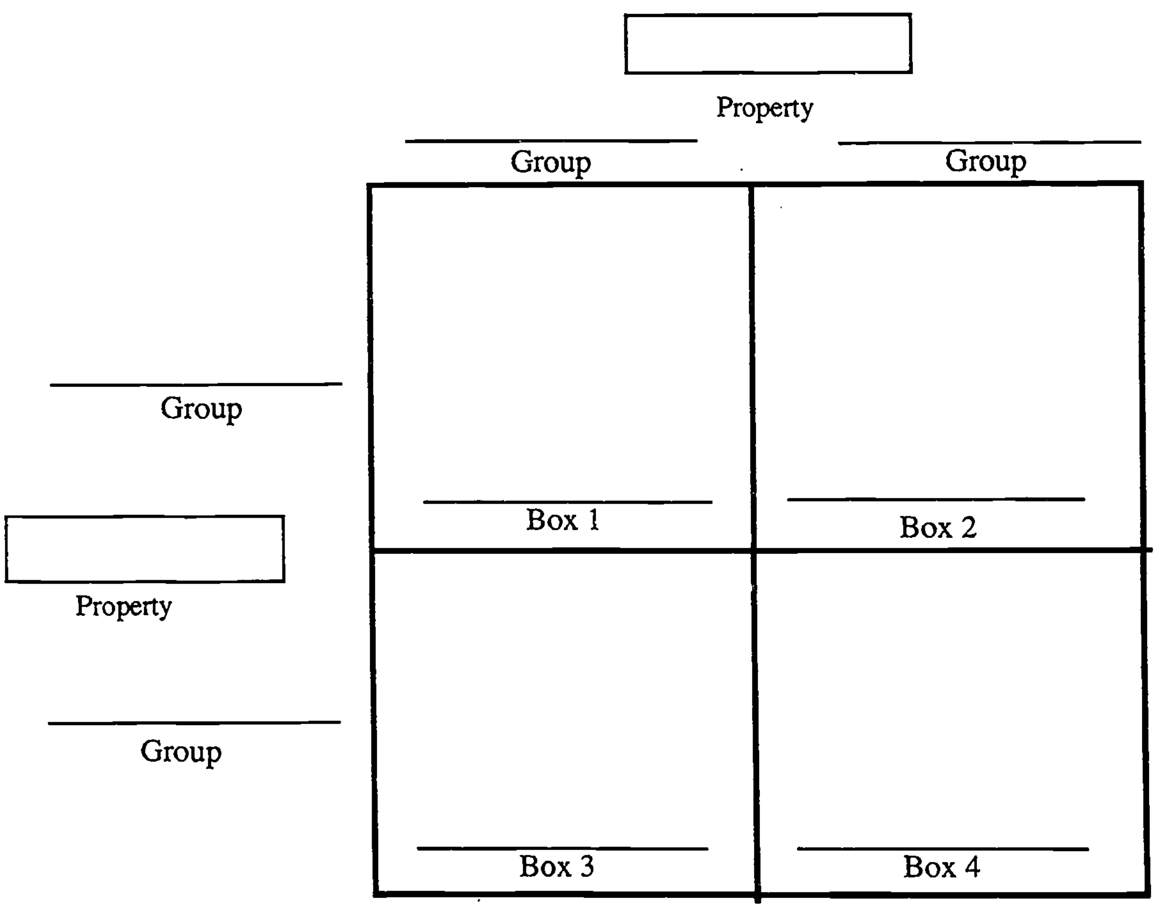
6. A few students started to classify the people in the envelope.

First, they chose two properties. One property is gender. It has two groups, male and female. They wrote this property and its groups on top of the table below. The other property is headwear. Headwear also has two groups, cap and no cap. The students wrote these labels on the side of the table.

Second, they wrote labels inside each box. Box 1 is labeled "male-cap" because it is under the male group and next to the cap group. Box 2 is "female-cap" because it is under the female group and next to the cap group. Box 3 is "male-no cap" and Box 4 is "female-no cap".

Third, they wrote "A" in Box 1 because picture **A** is a male <u>and</u> wearing a cap. They wrote "B" in Box 4 because **B** is female <u>and</u> not wearing a cap.

YOUR JOB is to finish the table below. Write each person's letter in the right box. Be sure to use all of the letters: C, D, E, F, G, H.



GO TO THE NEXT PAGE

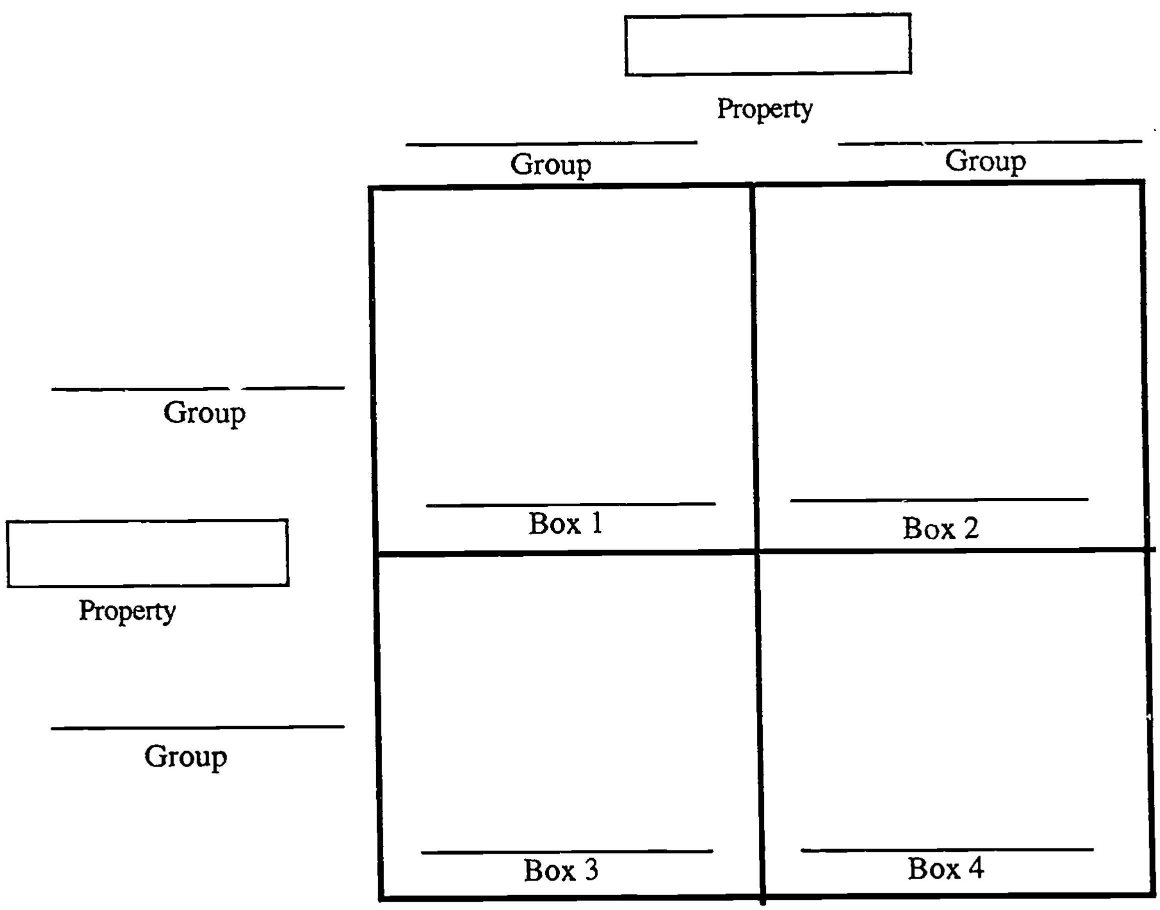
Task page 3

7. A second group of students started to sort the people using different properties but ran out of time.

YOUR JOB is to finish labeling all of the properties, groups, and boxes. Use the words below to do this.

Properties	**Groups**	**Boxes**
age	summer clothing	child-summer
clothing	winter clothing	child-winter
	adult	adult-summer
	child	adult-winter

Hint: Sort the pictures into the boxes on your placemat so you can see the groups they made. Some of the labels have been done already. The pictures in Box 4 have two things in common; they both show a child wearing summer clothing. That is why it has the "child-summer" label.



When you are finished, please put the figures back into the **"People"** envelope.

GO TO THE NEXT PAGE

Task page 4

Part 2: Sorting Animals

1. Take the animals out of **Envelope 1** and look at them carefully. Think about the different properties you could use to sort these animals into groups.

   Sort the animals into the four boxes using whatever properties and groups you want. Make sure to follow these rules:

   - Each box must have at least one animal.
   - You must use all eight animals.

YOUR JOB is to fill-in the table below. Be sure to label the properties, groups, and boxes. Write the letters of the animals in the boxes where they belong.

		Property	
		Group	Group
Property	Group	Box 1	Box 2
	Group	Box 3	Box 4

GO TO THE NEXT PAGE

Task page 5

2. Take the animal out of **Envelope 2**. Does this animal belong in any of the boxes in the table you just made? In the space below, describe which box this animal should be in and why. If the animal does not belong in any of the boxes, be sure to explain why.

When you are finished, please put the animals back into the envelopes.

STOP

Scoring Guide for Animals Classification

PART 1: Classifying People

QUESTION #2 (p.1)- max. 2 points

1 point for each valid similarity listed by the student, including: sitting, tired, people, in chairs, hand on knee, wearing shoes.

Student must clearly indicate two distinct similarities (e.g. "they are both sitting in chairs" would only get one point, while "both sitting, both in chairs" would get 2 points).

QUESTION #3 (p.1)- 1 point

1 point for identifying a valid difference, by:
- noting a characteristic that A has but B does not, (e.g., male, short hair, winter clothing), with or without a letter label; or,
- naming a dimension in which A and B differ (e.g. gender, season); or,
- noting a feature of both A and B, and including a label or descriptive adjective such that there is no ambiguity (e.g. "A is male and B is female", "He has summer clothes and she has winter clothes").

<u>No points</u> for ambiguous responses or responses that refer only to a characteristic of B, such as:

One is male, one is female
Summer Clothes
Female
Long hair
Short pants

QUESTION #4 (p.1)- 1 point for "No"

QUESTION #5 (p.1)- 1 point for "Yes"

QUESTION #6 (p.2)- max. 6 points

1 point each for placing the six pictures in the correct boxes.

	C
D,E,G	F,H

NOTE: Do not award points for A and B.

QUESTION #7 (p.3)- max. 7 points

1 point for each of the seven labels correctly placed.

Clothing
"Season" O.K.

	Adult	Child
	Adult-Winter	Child-Winter
Summer	Adult-Summer	

NOTE: Do not award points for Age, Winter, and Child-Summer.

PART 2: Classifying Animals

Follow these procedures in the order they are written.

QUESTION #1 (p.4)

1) COLUMN GROUPS: (2 points)
To get the 2 points for the column labels, the groups must meet TWO criteria:

a) Both groups must be part of the same variable. This means that the two groups in a column must be *mutually exclusive*.

b) There must be corroborating evidence of student understanding. This can be demonstrated by any one of the following methods:

1) Does the PROPERTY label fit both groups? (e.g. the property "Size" fits the groups "Big" and "Small") If not, then
2) Are the LABELS INSIDE THE BOXES consistent with the column group labels? If NOT, then
3) Are the ANIMALS in each column sorted in a way that is consistent with the group label for that column? (It does not have to be perfect).

50% RULE: If 50% or more of the animals in a column fit the label for that column, then it corroborates the column label. Both labels must be corroborated for the student to get credit for the group labels.

2) COLUMN PROPERTY: (1 point) Both column groups must fit the property.

MAMMAL RULE: Student does not receive a point if he or she uses the same label for a group and for the corresponding property, unless student says "OR", uses a question mark, or somehow recognizes a dichotomy between the groups in the property label. For example, "mammal" is not OK, but "mammal or not mammal" is OK.

NOTE: If a student uses the same property or group labels for the rows and columns, he/she can only receive points once.

3) ROW GROUPS: (2 points)
Same criteria as column groups (see above).

4) ROW PROPERTY: (1 point)
Both row groups have to fit the property (see above).

5) BOX LABELS: (1 point each up to 4 points)
Each inside box label must match its outside row AND column group labels. Close synonyms are acceptable (e.g., outside group label is "Big" and the corresponding box label says "large", this is OK).

6) ANIMALS: (1 point each up to 8 points)
Does the animal fit the box? Give first priority to the outside group labels. Animals placed in more than one box cannot receive a point. A student can get all 8 points for animals only if every box has at least one animal. If this rule is not satisfied, but all the animals are classified properly, then assign a score of "7" for animals.

See page 9 "Specific Rules for Scoring Animals" for guidelines on ambiguous groupings, such as "big/small". **Remember, a student can get points here even if he or she did not get points for the groups (see "Special Cases", p.5).**

QUESTION #2 (p.5) - (1 point)

Student receives 1 point if his or her response is accurate relative to his or her own classification system. Student must identify a box or boxes, or give valid reasons for not placing the object in a box.

GIVE POINT IF ANY OF THE STUDENT'S <u>EXPLANATION</u> CONTAINS ANY OF THE FOLLOWING:

a) A unique box label that is valid (applies to characteristics of the alligator) - for example, *lays eggs*

b) Row and column labels that are valid - for example, *big* and *water*

c) Box number AND either row or column label, both of which are valid

d) Student mentions more than one box and gives valid reason for why the object fits into each box - for example, can go in Box 1 (land/big) or Box 2 (water/big)

e) Student says object doesn't fit any box and gives valid reason that is consistent with his or her system.

Give the student a point if the explanation satisfies one or more of the rules above. A student who does not receive a point is most likely to:

a) Provide a box number only, with no reason (needs at least one word)

b) Put object in a box and provide a reason that is inconsistent with his or her labels or classification system

c) Mention a row or column without specifying a particular box or stating why both boxes would be applicable.

If there is an internal conflict (e.g., fits box label but not row and column labels), student gets the benefit of the doubt and receives a point.

SPECIAL CASES:

a) One or both sets of groups labels do not constitute levels of a variable (e.g., *big* and *dark*)

AND

b) Student has a valid cross-classification *within* the table.

Ways in which this may occur:

- Outside labels do not represent levels of a variable, but student uses these to create a cross-classification inside the table and this cross-classification makes sense. (See "pointy faces" example from calibration and example 1a in this handout.)

  SCORING: No points for group labels that are not levels of a variable. 1 point awarded for each correct box label (box label that contains each of the corresponding row and column labels) 1 point awarded for each properly classified animal

- Group labels are missing but the box labels show a valid cross-classification. (See example 2a in this handout.)

  SCORING: No points awarded for groups or properties
  No points awarded for boxes
  1 point awarded for each properly classified animal

- Group labels *conflict* with the box labels inside the table, but the box labels and animals form a valid cross-classification within the table. (See example 3a in this handout.)

  SCORING: Points awarded for groups only if they can be corroborated by an appropriate property label
  No points awarded for boxes
  1 point awarded for each properly classified animal

IMPORTANT:

In order for a student to receive points for animals in these special cases:

a) There must be evidence that the row group applies to both boxes in the row; in other words, the student must have at least one animal that fits the group label in *each* of the boxes in that row. There must also be evidence that the column group applies to both boxes in the column; student must have at least one animal that fits the column label in *each* of the boxes in that column.

b) 50% Rule: At least 50% of the animals in each row must fit that row, whether the student is using external labels or box labels. At least 50% of the animals in each column must fit that column.

Example 1a

		where	
		land	sea
size	wild	elephant tiger dog	shark whale
	dark	chicken duck	seal

Example 1a: SCORING

There is evidence of an internal cross-classification based on the animals in the boxes. Elephant, tiger, and dog fit the wild-land box (if we consider that a dog may be wild), shark and whale fit the wild-sea box, chicken fits the dark-land box, and seal fits the dark-sea box. Therefore this represents one of our special cases.

1) Column groups

FIRST, Are both groups levels of the same variable?
- *land* and *sea* are levels of *a variable*

SECOND, Is there corroborating evidence?
Step 1: Check property label.
- *land* and *sea* are levels of *where* — 2 points

2) Column property

Do both column groups fit the property?
- *land* and *sea* are levels of *where* — 1 point

3) Row groups

FIRST, Are both groups levels of the same variable?
- *wild* and *dark* are not levels of a variable — 0 points

4) Row property

No points for property because row groups are not levels of a variable. — 0 points

5) Box labels

Missing, so no points — 0 points

6) Animals

Does the animal fit the box?
- We may award points for 7 of the 8 animals, as discussed above — 7 points

Example 2a

	animals	
animals	killer whale sea-big	seal shark sea-small
	elephant tiger land-big	duck chicken dog land-small

Example 2a: SCORING

There is evidence of an internal cross-classification based on the box labels and the animals in the boxes.

1) Column groups

    Missing — <u>0 points</u>

2) Column property — <u>0 points</u>

3) Row groups

    Missing — <u>0 points</u>

4) Row property — <u>0 points</u>

5) Box labels

    Do not correspond to outside row and column labels — <u>0 points</u>

6) Animals

    Does the animal fit the box?

    - Based on this student's internal cross-classification, we may award points for all 8 animals.

    <u>8 points</u>

Example 3a

		water	
		water	no water
habitat	no water	chicken dog small-no water	elephant tiger big-no water
	water	seal duck small-water	killer whale shark big-water

Example 3a: SCORING

This student has used the same group labels for rows and columns. These labels conflict with what is in the box labels. Because the box labels form a valid cross-classification, we may award points for animals.

1) Column groups

FIRST, Are both groups levels of the same variable?
• *water* and *no water* are levels of a variable

SECOND, Is there corroborating evidence?
Step 1: Check property label.
• *water* and *no water* are not levels of *water* (see mammals rule)
• box labels do not corroborate these groups
• animals do not corroborate these groups — <u>0 points</u>

2) Column property
Do both column groups fit the property?
• *water* and *no water* are not levels of *water* — <u>0 points</u>

3) Row groups
FIRST, Are both groups levels of the same variable?
• *water* and *no water* are levels of *habitat* — <u>2 points</u>

4) Row property
• *no water* and *water* are levels of *habitat* — <u>1 point</u>

5) Box labels
Do not correspond to outside row and column labels — <u>0 points</u>

6) Animals
Does the animal fit the box?
• We may award points for all 8 animals, based on the internal cross-classification. — <u>8 points</u>

SPECIFIC RULES SCORING ANIMALS

Animal Sizes

Student has groups based on animal sizes (e.g., big/small)

Must Always Be Big	Must Always Be Small	Flexible
Elephant Whale	Chicken Duck/Goose	Dog Seal Shark Tiger

Light/Dark Animals

Student uses "light" and "dark" as groups (exactly these words)

Must Always Be Dark	Must Always Be Light	Flexible
Seal Whale	Duck/Goose Shark	Chicken Dog Elephant Tiger

Animal Colors

Student has groups based on how colorful the animals are. Colorful, Multicolored, and "more than 1 color" should be considered the same thing.

Must Always Be Multicolored	Must Always Be One Color	Flexible
Dog Tiger Whale	Elephant	Chicken* Duck Seal Shark

* If the chicken is one color then the duck MUST also be considered one color in the student's system. But, the duck can be one color without the chicken also being considered one color.

Rater Answer Form -- Classification of Animals

Rater Name: ______________________________ Date: July ___, 1993

Rater ID Number: ________ (RAND use only) Starting Time: ___ : ___ AM/PM

Instructions: Circle the number of points awarded for each question.

Student ID Number	Item 2	3	4	5	Item 6	Item 7	Properties	Groups	Boxes	Animals	2
___-___-_____ -41	0 1 2	0 1	0 1	0 1	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7	0 1 2	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4 5 6 7 8	0 1
___-___-_____ -41	0 1 2	0 1	0 1	0 1	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7	0 1 2	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4 5 6 7 8	0 1
___-___-_____ -41	0 1 2	0 1	0 1	0 1	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7	0 1 2	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4 5 6 7 8	0 1
___-___-_____ -41	0 1 2	0 1	0 1	0 1	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7	0 1 2	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4 5 6 7 8	0 1
___-___-_____ -41	0 1 2	0 1	0 1	0 1	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7	0 1 2	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4 5 6 7 8	0 1
___-___-_____ -41	0 1 2	0 1	0 1	0 1	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7	0 1 2	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4 5 6 7 8	0 1
___-___-_____ -41	0 1 2	0 1	0 1	0 1	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7	0 1 2	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4 5 6 7 8	0 1
___-___-_____ -41	0 1 2	0 1	0 1	0 1	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7	0 1 2	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4 5 6 7 8	0 1
___-___-_____ -41	0 1 2	0 1	0 1	0 1	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7	0 1 2	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4 5 6 7 8	0 1
___-___-_____ -41	0 1 2	0 1	0 1	0 1	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7	0 1 2	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4 5 6 7 8	0 1
___-___-_____ -41	0 1 2	0 1	0 1	0 1	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7	0 1 2	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4 5 6 7 8	0 1
___-___-_____ -41	0 1 2	0 1	0 1	0 1	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7	0 1 2	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4 5 6 7 8	0 1
___-___-_____ -41	0 1 2	0 1	0 1	0 1	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7	0 1 2	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4 5 6 7 8	0 1
___-___-_____ -41	0 1 2	0 1	0 1	0 1	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7	0 1 2	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4 5 6 7 8	0 1
___-___-_____ -41	0 1 2	0 1	0 1	0 1	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7	0 1 2	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4 5 6 7 8	0 1
___-___-_____ -41	0 1 2	0 1	0 1	0 1	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7	0 1 2	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4 5 6 7 8	0 1
___-___-_____ -41	0 1 2	0 1	0 1	0 1	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7	0 1 2	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4 5 6 7 8	0 1
___-___-_____ -41	0 1 2	0 1	0 1	0 1	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7	0 1 2	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4 5 6 7 8	0 1
___-___-_____ -41	0 1 2	0 1	0 1	0 1	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7	0 1 2	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4 5 6 7 8	0 1
___-___-_____ -41	0 1 2	0 1	0 1	0 1	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7	0 1 2	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4 5 6 7 8	0 1

7. Classification of Materials

The materials classification task was designed by RAND and administered to sixth-grade students in 1993 and to eighth-grade students in 1994. The shell used for designing this task is identical to that for the classification of animals task (see Section 6).

Two tasks were developed from this shell. In the tasks, two-way classification is explained using pictures of people who differ in terms of age (old and young), position (sitting or standing), gender (male or female), and type of clothing (summer or winter). Students are shown how to classify the pictures into four mutually exclusive groups using two dimensions simultaneously (e.g., young-males, old-males, young-women, and old-women). This activity is the same in both tasks. In the materials classification task, students are given a collection of natural materials (e.g., sand, fur, rock, and pine cone) and are asked to create a two-way classification system. Then they are given a new material, a pencil, and asked where it fits in their system and why. The first task (see Section 6) involves animals.

The components of the materials task will be found on the following pages:

Note: Two scoring guides are included. One was used in 1993 (when the tasks were administered to 6th grade students); the other was used in 1994 (when the tasks were given to 7th and 8th grade students). They reflect different approaches to awarding points for incomplete or contradictory responses—not different views of the desired outcomes. The change was made in 1994 to try to make the scoring process more efficient.

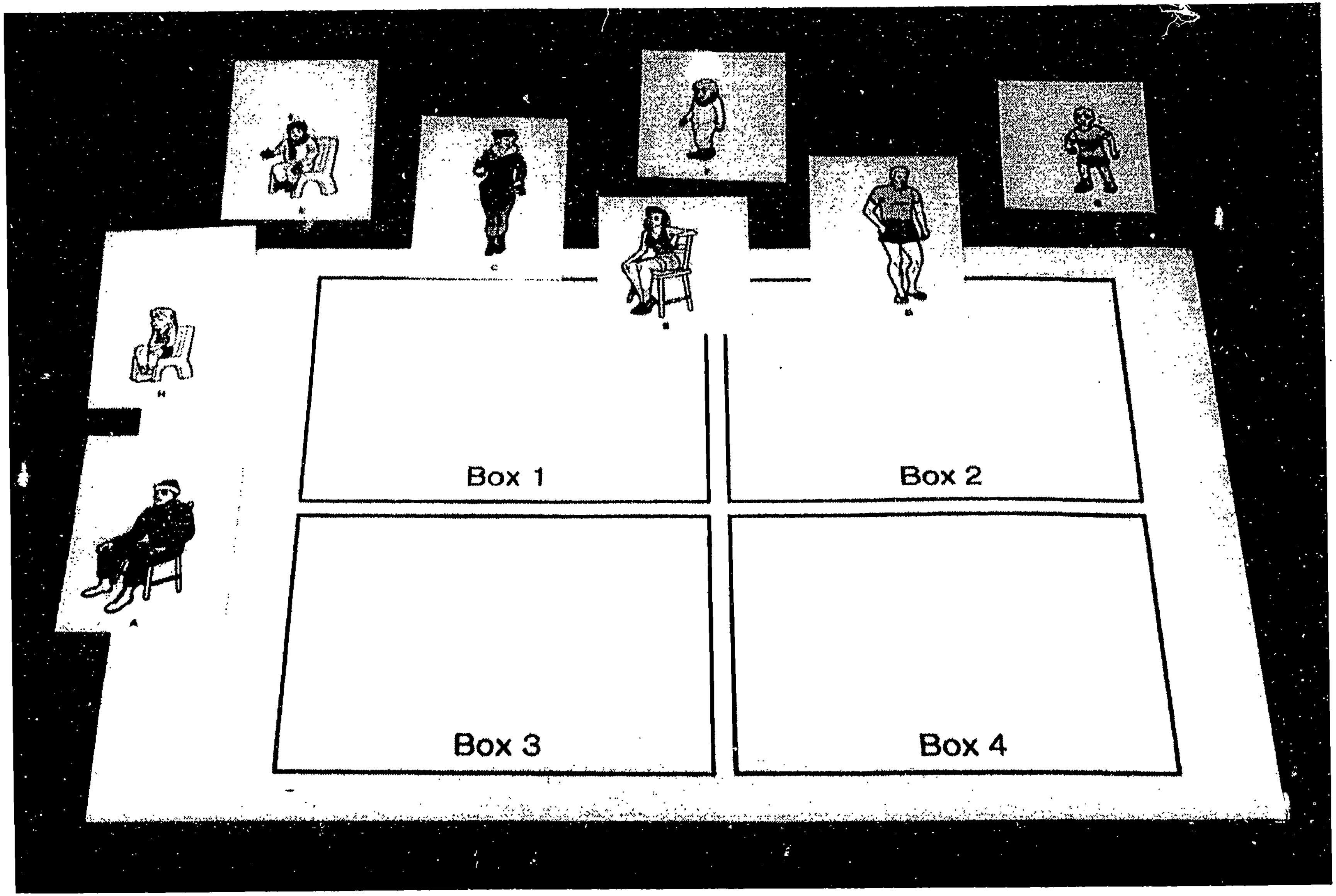


Figure 8—Equipment for Classification of Materials (Tuning Task)

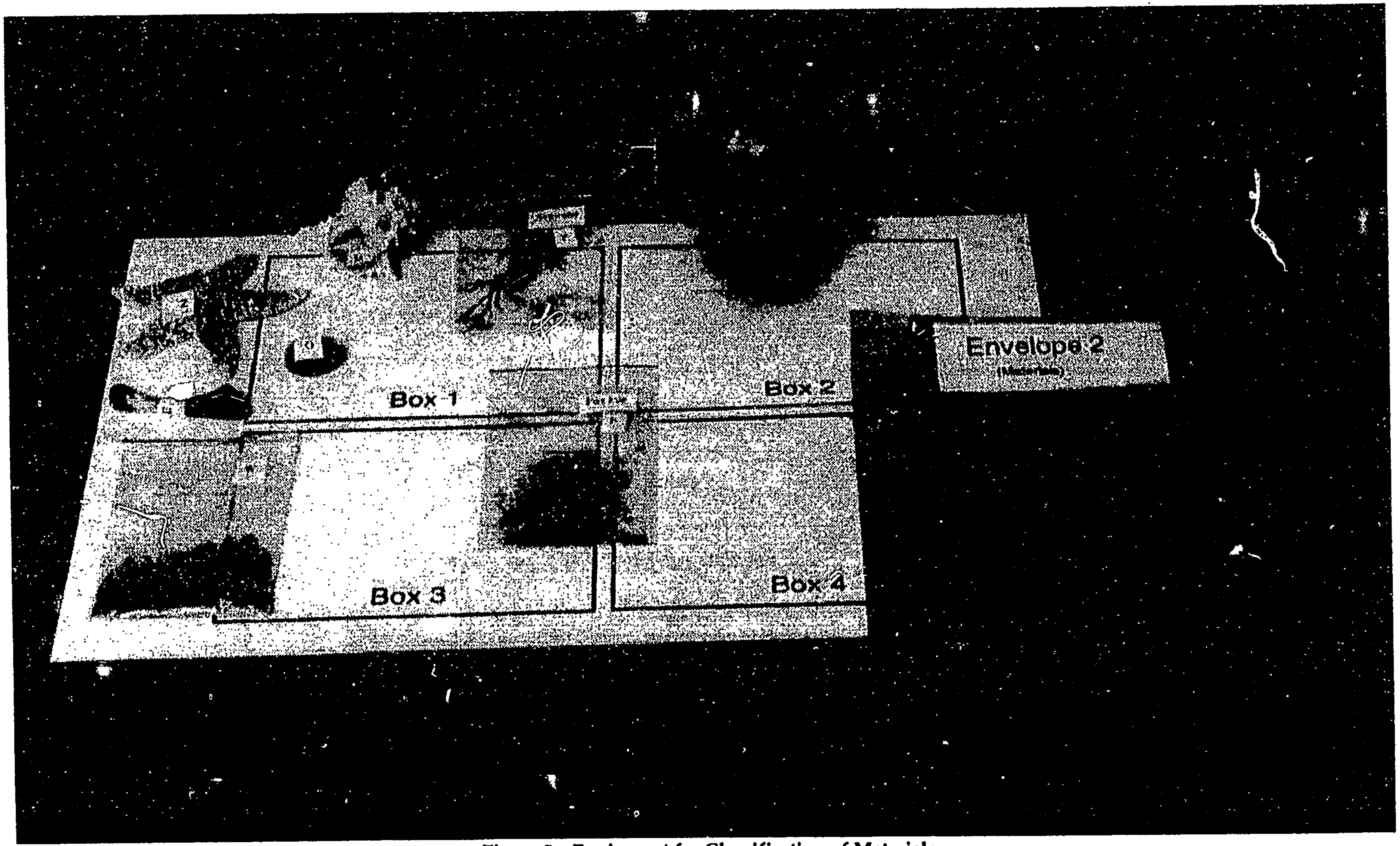


Figure 9—Equipment for Classification of Materials

Task page 1

Name: ______________________
First Last

Date: ______________________

Do not write in this box.
ID: ________
SCH: ________
CLS: ________

Classification

Part 1: Sorting People

The ways in which objects differ are called properties. Properties can be used to sort objects into groups. Color is one property you could use to classify cars. You might sort cars into two groups based on their color: blue and not blue. Another car property is speed. There could be two speed groups: fast and slow. You also could classify cars by how many doors they have. One group has 2 doors, another group has 4 doors, and so on. There are many different properties you could use to classify things.

1. Take the pictures out of the envelope labeled **"People"**.

2. Look at pictures **A** and **B**. List two ways the people in **A** and **B** are similar to each other:

   ____

   ____

3. List one way **A** is different from **B**:

   ____

4. Gender is one property. Every person is either male or female. Gender could be used to sort people into two groups; one group is males and the other is females.

   Do **A** and **B** belong to the same gender group? (Circle one answer)

   Yes No

5. Another property is body position. You can use this property to divide people into two groups: sitting and standing.

   Do **A** and **B** belong to the same body position group? (Circle one answer)

   Yes No

GO TO THE NEXT PAGE

Task page 2

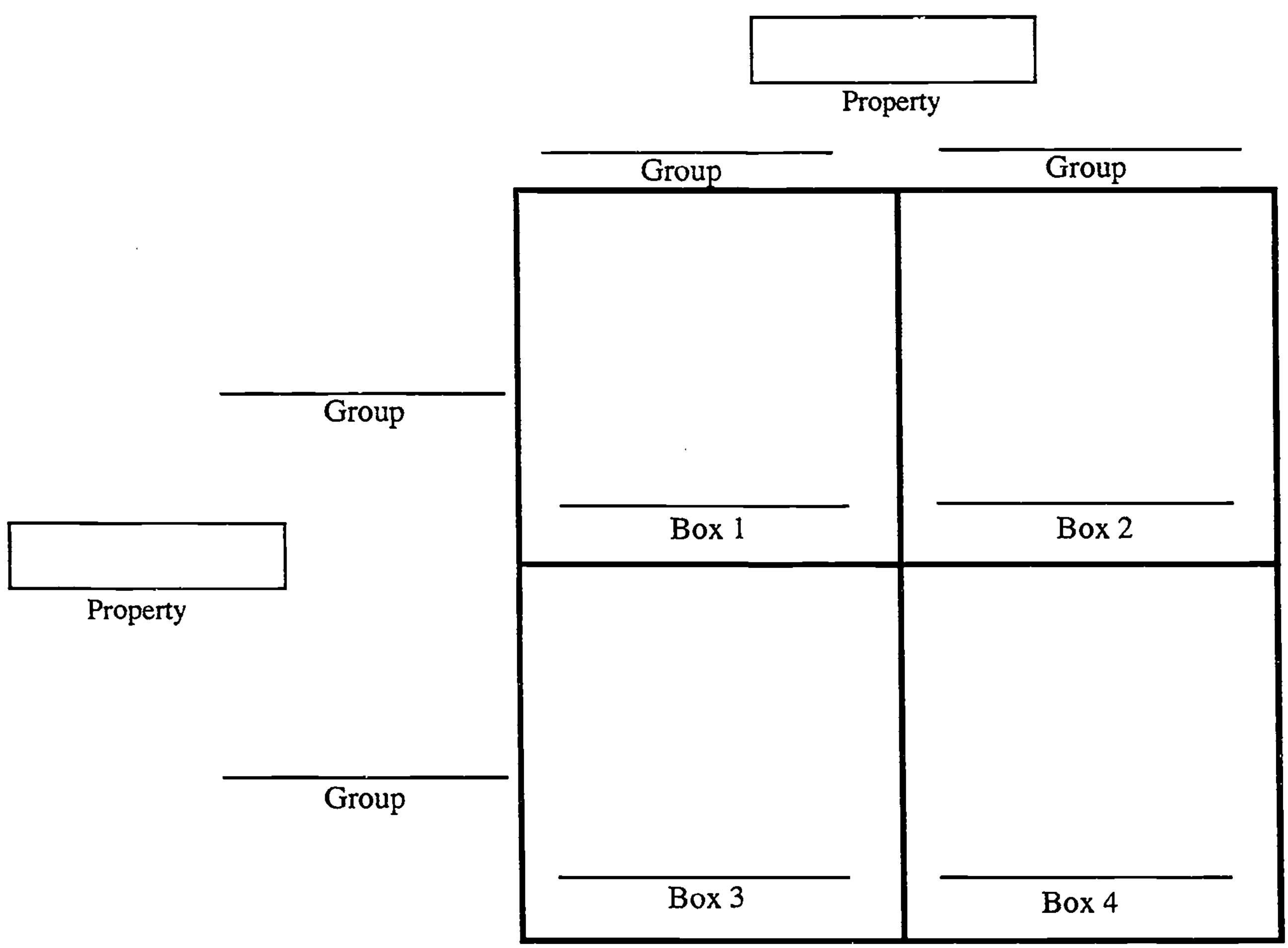
6. A few students started to classify the people in the envelope.

   First, they chose two properties. One property is gender. It has two groups, male and female. They wrote this property and its groups on top of the table below. The other property is headwear. Headwear also has two groups, cap and no cap. The students wrote these labels on the side of the table.

   Second, they wrote labels inside each box. Box 1 is labeled "male-cap" because it is under the male group and next to the cap group. Box 2 is "female-cap" because it is under the female group and next to the cap group. Box 3 is "male-no cap" and Box 4 is "female-no cap".

   Third, they wrote "A" in Box 1 because picture **A** is a male <u>and</u> wearing a cap. They wrote "B" in Box 4 because **B** is female <u>and</u> not wearing a cap.

   YOUR JOB is to finish the table below. Write each person's letter in the right box. Be sure to use all of the letters: C, D, E, F, G, H.



GO TO THE NEXT PAGE

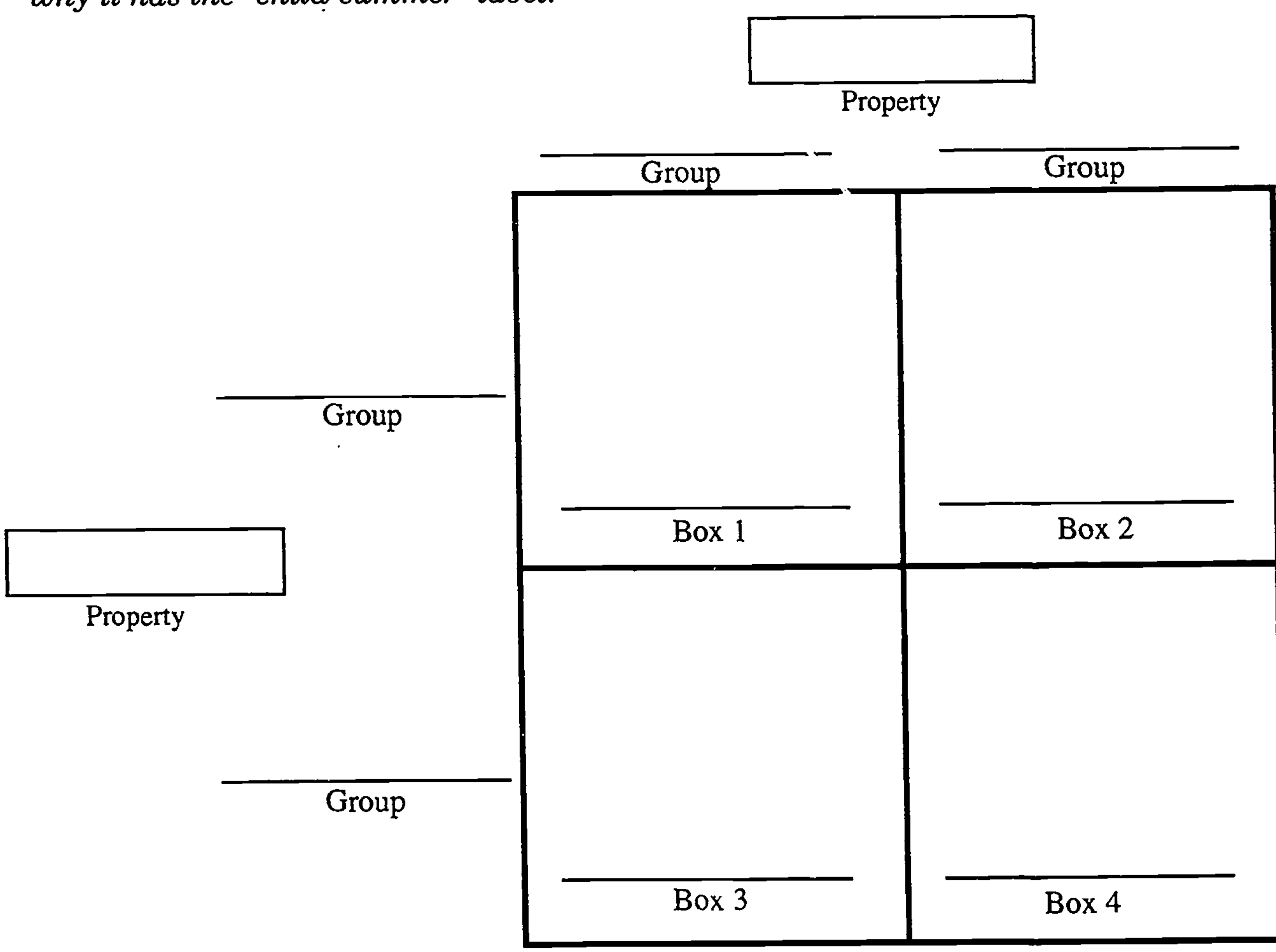
Task page 3

7. A second group of students started to sort the people using different properties but ran out of time.

   YOUR JOB is to finish labeling all of the properties, groups, and boxes. Use the words below to do this.

Properties	**Groups**	**Boxes**
age	summer clothing	child-summer
clothing	winter clothing	child-winter
	adult	adult-summer
	child	adult-winter

Hint: Sort the pictures into the boxes on your placemat so you can see the groups they made. Some of the labels have been done already. The pictures in Box 4 have two things in common; they both show a child wearing summer clothing. That is why it has the "child-summer" label.



When you are finished, please put the figures back into the "**People**" envelope.

GO TO THE NEXT PAGE

Task page 4

Part 2: Sorting Materials

1. Take the materials out of **Envelope 1** and look at them carefully. Think about the different properties you could use to sort these materials into groups.

   Sort the materials into the four boxes using whatever properties and groups you want. Make sure to follow these rules:

   - Each box must have at least one material.
   - You must use all eight materials.

YOUR JOB is to fill-in the table below. Be sure to label the properties, groups, and boxes. Write the letters of the materials in the boxes where they belong.

Property

		Group	Group
Property	Group	Box 1	Box 2
	Group	Box 3	Box 4

GO TO THE NEXT PAGE

Task page 5

2. Take the material out of **Envelope 2**. Does this material belong in any of the boxes in the table you just made? In the space below, describe which box this material should be in and why. If the material does not belong in any of the boxes, be sure to explain why.

When you are finished, please put the materials back into the envelopes.

STOP

SCORING GUIDE: MATERIALS - CLASSIFICATION 1993 - 6th GRADE

PART 1: Classifying People

QUESTION #2 (p.1)- max. 2 points
1 point for each valid similarity listed by the student, including: sitting, tired, in chairs, hand on knee, wearing shoes. Not acceptable: people, humans, homosapiens, both have eyes (ears, arms, etc.).

Student must clearly indicate two distinct similarities (e.g. "they are both sitting in chairs" would only get one point, but "both sitting, both in chairs" would get 2 points).

QUESTION #3 (p.1)- 1 point

1 point for <u>any valid difference.</u>

For example, <u>award a point</u> if student answers:

Gender
Male/Female
A is male
B is female
Different sex
A is male, B is female
Clothing
Short hair/long hair
Male (a valid characteristic of A)
One is male, one is female
Short pants/long pants
He has a hat (but not: "a hat")
One is wearing a cap, the other isn't

<u>Ways in which student may fail to earn a point:</u>
- Answer that is clearly wrong (e.g., one is adult, one is child)
- Switch characteristics of A and B (e.g., A is female, B is male)
- Illegible response

QUESTION #4 (p.1)- 1 point for No

QUESTION #5 (p.1)- 1 point for Yes

QUESTION #6 (p.2)- Max. 6 points
1 point each for placing the six pictures in the correct boxes.

	C
D, E, G	F, H

Note: Do not award points for A and B.

QUESTION #7 (p.3) - max. 7 points

1 point for each of the seven labels correctly placed.

	Adult	**Child**
Clothing "season" O.K.	**Adult-Winter**	**Child-Winter**
Summer	**Adult-Summer**	

NOTE: Do not award points for Age, Winter, and Child-Summer.

PART 2: CLASSIFYING MATERIALS

Follow these procedures in the order in which they are written.

QUESTION # 1 (P.4)

1) COLUMN GROUPS: (2 points)
   To get the 2 points for the column labels, the groups must meet TWO criteria

   a) Both groups must be part of the same variable. This means that the two groups in a column must be *mutually exclusive*.

   b) There must be corroborating evidence of student understanding. This can be demonstrated by any one of the following methods:

      1. Does the PROPERTY label fit both groups? (e.g. the property "Size" fits the groups "Big" and "Small") If not, then

      2. Are the LABELS INSIDE THE BOXES consistent with the column group labels? If NOT, then

      3. Are the MATERIALS in each column sorted in a way that is consistent with the group label for that column? (It does not have to be perfect.)

      50% RULE: If 50% or more of the materials in a column fit the label for that column, then it corroborates the column label. Both labels must be corroborated for the student to get credit for the group labels.

      "DEAD" RULE: If student uses dead/living (alive) for groups, deduct 1 point for groups and read "dead" as "inorganic" (but "dead" & "never living" are OK as groups).

2) COLUMN PROPERTY: (1 point) Both column groups must fit the property.

   MAMMAL RULE: Student does not receive a point if he or she uses the same label for a group and for the corresponding property, unless student says "OR," uses a question mark, or somehow recognizes a dichotomy between the groups in the property label. For example, "mammal" is not OK, but "mammal or not mammal" is OK.

NOTE: If a student uses the same property or group labels for the rows and columns, he/she can only receive points once.

3) ROW GROUPS: (2 Points)
   Same criteria as column groups (see above).

4) ROW PROPERTY (1 points)
   Both row groups have to fit the property (see above).

5) BOX LABELS: (1 point each up to 4 points)
   Each inside box label must match its outside row AND column group labels. Close synonyms are acceptable (e.g., outside group label is "Big" and the corresponding box label says "large," is OK).

6) MATERIALS: (1 point each up to 8 points)
Does the material fit the box? Give first priority to the outside group labels. Materials placed in more than one box cannot receive a point. A student can get all 8 points for materials only if every box has at least one material. If this rule is not satisfied, but all the materials are classified properly, then assign a score of "7" for materials.

See page 13 "Chart for Scoring Materials" for guidelines on how to score each object. **"Remember, a student can get points here even if he or she did not get points for the groups (see "Special Cases," p.5).**

QUESTION # 2 (P.5) - 1 point

Student receives 1 point if his or her response is accurate relative to his or her own classification system. Student must identify a box or boxes, or give valid reasons for not placing the object in a box.

GIVE POINT IF ANY OF THE STUDENT'S EXPLANATION CONTAINS ANY OF THE FOLLOWING:

A) A unique box label that is valid (applies to characteristics of the pencil) - for example, *comes from trees*.

b) Row and column labels that are valid - for example, *smooth and not alive*.

c) Box number AND either row or column label, both of which are valid.

d) Student mentions more than one box and gives valid reason for why the object fits into each box - for example, can go in Box 1 (organic/big) or Box 2(inorganic/big).

e) Student says object doesn't fit any box and gives valid reason that is consistent with his or her system.

Give the student a point if the explanation satisfies one or more of the rules above. A student who does not receive a point is most likely to:

a) Provide a box number only, with no reason (needs at lease one word)

b) Put object in a box and provide a reason that is inconsistent with his or her labels or classification system.

c) Mention a row or column without specifying a particular box or stating why both boxes would be applicable.

If there is an internal conflict (e.g., fits box label but not row and column labels), student gets the benefit of the doubt and receives a point.

SPECIAL CASES:

a) One or both sets of groups labels do not constitute levels of a variable (e.g., *big and dark*).

AND

b) Student has a valid cross-classification *within* the table.

Ways in which this may occur:

- Outside labels do not represent levels of a variable, but student uses these to create a cross-classification inside the table and this cross-classification makes sense. (See examples 1A & 1B in this handout.)

  SCORING: No points for group labels that are not levels of a variable.
  1 point awarded for each correct box label (box label that contains each of the corresponding row and column labels)
  1 point awarded for each properly classified material.

- Group labels are missing but the box labels show a valid cross-classification. (See examples 2A & 2B in this handout.)

  SCORING: No points awarded for groups or properties
  No points awarded for boxes
  1 point awarded for each properly classified material

- Group labels *conflict* with the box labels inside the table, but the box labels and materials form a valid cross-classification with in the table. (See examples 3A & 3B in this handout.)

  SCORING: Points awarded for groups only if they can be corroborated by an appropriate property label
  No points awarded for boxes
  1 point awarded for each properly classified material

IMPORTANT:

In order for a student to receive points for materials in these special cases:

a) For row groups that are not legitimate, there must be at least one properly classified material in each box in a row for student to get points for any materials in that row. For column groups that are not legitimate, there must be at least one properly classified material in each box in a column for student to get points for *any* materials in that column.

b) 50% Rule: At least 50% of the materials in each row must fit that row, whether the student is using external labels or box labels. At least 50% of the materials in each column must fit that column.

Example 1A: 1 pair of legitimate groups, 1 pair of non-legitimate groups

		home	
		ocean	land
size	alive	seaweed sea star shell	pine cone bone fox fur
	smooth	sand	rock

Example 1A: SCORING

There is evidence of an internal cross-classification based on the materials in the boxes. Seaweed, sea star, and shell fit the ocean-alive box, pine cone, fur, and bone fit the land-alive box, sand fits the ocean-smooth box, and rock fits the land-smooth box. Therefore this represents one of our special cases.

1) Column groups
   FIRST, are both groups levels of the same variable?
   - ocean and land are levels of a variable.

   SECOND, is there corroborating evidence?
   Step 1: Check property label.
   - *ocean* and *land* are levels of home — 2 points

2) Column property
   Do both column groups fit the property?
   - *ocean* and *land* are levels of home — 1 point

3) Row groups
   Are both groups levels of the same variable?
   - *alive* and *smooth* are not levels of a variable — 0 points

4) Row property
   No points for property because row groups are not levels of a variable. — 0 points

5) Box labels
   Missing, so no points — 0 points

6) Materials
   Does the material fit the box?
   - we may award points for all 8 materials, as discussed above — 8 points

Variation of Example 1A:

		home	
		ocean	land
size	alive	seaweed sea star shell	pine cone bone fox fur
	smooth	sand rock	

This student receives a score of 6 for materials. Student does not have at least 1 properly classified material in each box in the "smooth" row and therefore can receive no points for materials in that row. Student gets all 6 points for materials in the top row. (Remember, we can award points for the "land" column, even though there is not 1 material in each box, because it is part of a legitimate pair of groups.)

Example 1B: 2 non-legitimate pairs of groups

	big	rough
alive	sea star pine cone	shell seaweed fur
smooth	bone rock	sand

This student receives 0 points for properties, groups, and boxes. Using the 50% rule, we see that there is a cross-classification even though neither pair of groups is legitimate. Based on this student's system, and using our chart, we can award 6 points for materials (sea star, pine cone, shell, seaweed, bone, & sand).

Variation of example 1B:

	big	rough
alive	sea star pine cone	shell seaweed fur
smooth	bone rock	

If sand is missing from box 4, student can get only 2 points for materials. The "rough" column does not contain at least 1 properly classified material in each of its boxes, and the "smooth" column does not contain at least 1 properly classified material in each of its boxes. Therefore we can award no points for any of the materials in the "rough" column or in the "smooth" row. This student receives points for star and pine cone.

Example 2A: Group labels missing, but all 4 box labels form a valid cross-classification

	animals	
	sea star bone shell animals-hard	fox fur animals-soft
plants	pine cone rock non-animals-hard	sand seaweed non-animals-soft

Example 2A: SCORING

There is evidence of an internal cross-classification based on the box labels and the materials in the boxes.

1) Column groups
   Missing — <u>0 points</u>

2) Column property — <u>0 points</u>

3) Row groups
   Missing — <u>0 points</u>

4) Row property — <u>0 points</u>

5) Box labels
   Do not correspond to outside row and column labels — <u>0 points</u>

6) Materials
   Does the material fit the box?

   - Based on this student's internal cross-classification, we may award points for all 8 materials. — <u>8 points</u>

Example 2B: No group labels, and one box label missing, wrong, or incomplete.

	animals	
	sea star bone shell animals-hard	fox fur animals-soft
plants	pine cone rock non-animals-hard	sand seaweed soft

If a box label is missing, incorrect, or incomplete, student receives no points for materials in that row or column. This student receives 3 points for materials (sea star, bone, & shell).

Example 3A: Conflict between inside and outside labels, but all 4 boxes form a valid cross-classification

		big	
		alive	not alive
small	alive	fox fur seaweed bone smooth-alive	shell sea star pine cone rough-alive
	not alive	rock smooth-not alive	sand rough-not alive

Example 3A: SCORING

This student has used the same group labels for rows and columns. These labels conflict with what is in the box labels. Because the box labels form a valid cross-classification, we may award points for materials.

1) Column groups
   FIRST, are both groups levels of the same variable?
   - *alive* and *not alive* are levels of a variable

   SECOND, is there corroborating evidence?

   Step 1: Check property label.
   - *alive* and *not alive* are not levels of *big*
   - box labels do not corroborate these groups
   - materials do not corroborate these groups — 0 points

2) Column property
   Do both column groups fit the property?
   - *alive* and *not alive* are not levels of *big* — 0 points

3) Row groups
   FIRST, are both groups levels of the same variable?
   - *alive* and *not alive* are not levels of *small*
   - box labels corroborate group labels — 2 points

4) Row property
   - *alive* and *not alive* are not levels of *small* — 0 points

5) Box labels
   Do not correspond to outside row and column labels — 0 points

6) Materials
   Does the material fit the box?
   - We may award points for all 8 materials, based on the internal cross-classification. — 8 points

Example 3B: Conflict between inside and outside labels; 1 box label missing, incorrect, or incomplete

		big	
		alive	not alive
small	alive	fox fur seaweed bone smooth-alive	shell sea star pine cone rough-alive
	not alive	rock smooth-not alive	sand

Because Box 4 label is missing, we cannot award points for any materials in that row or column. This student receives points for materials in box 1: 3 points for fur, seaweed, and bone.

CHART FOR SCORING MATERIAL
Objects

	Y SeaW	Z/N Star	D Shell	E Bone	F Fur	X Cone	G Rock	W/M Sand	A Pen
GROUPS:									
Beach	Y	Y	Y	Y	N	Y	Y	Y	N
Water/Ocean/Sea	Y	Y	Y	Y	N	N	Y	Y	N
Land/Forest/Mountain	N	N	N	Y	Y	Y	Y	Y	Y
Desert	N	N	N	Y	N	N	Y	Y	N
Reproduce	Y	Y	Y	Y	Y	Y	N	N	N
Not Reproduce	N	N	Y	N	Y	N	Y	Y	Y
Living/Once Live	Y	Y	Y	Y	Y	Y	N	N	Y
Growing/Organic	Y	Y	Y	Y	Y	Y	N	N	Y
Not-Living	Y	N	N	N	N	N	Y	Y	Y
In-organic/Mineral	Y	N	N	N	N	N	Y	Y	Y
Dead* (see dead rule)	Y	N	N	N	N	N	Y	Y	Y
Natural	Y	Y	Y	Y	Y	Y	Y	Y	N
Man Made	Y	N	N	N	N	N	N	N	Y
Sharp	N	Y	Y	N	N	Y	N	N	N
Blunt	Y	N	N	Y	N	N	Y	N	Y
Prickly	Y	Y	Y	N	N	Y	N	N	N
Rough/Coarse	Y	Y	Y	N	N	Y	N	Y	N
Smooth	Y	N	N	Y	Y	N	Y	Y	Y
Bumpy	Y	Y	Y	Y	N	Y	N	Y	Y
Hard	N	Y	Y	Y	N	Y	Y	Y	Y
Soft	Y	N	N	N	Y	N	N	Y	N
Smelly	Y	Y	Y	Y	Y	Y	N	N	N
Not Smelly	Y	N	Y	N	Y	N	Y	Y	Y
Breakable	Y	Y	Y	Y	N	Y	Y	N	Y
Jagged	Y	Y	Y	N	N	Y	N	N	N
Pointy	Y	Y	Y	N	N	Y	N	N	Y
Curved/Round	Y	N	Y	Y	Y	Y	Y	N	Y
Straight	N	N	N	Y	Y	N	N	N	Y
Long	Y	N	N	Y	Y	N	N	N	Y
Flat	Y	N	N	N	Y	N	Y	Y	N
Animal/Active	N	Y	Y	Y	Y	N	N	N	N
Plant	Y	N	N	N	N	Y	N	N	Y
Human	N	N	N	Y	N	N	N	N	N
Not Human	Y	Y	Y	Y	Y	Y	Y	Y	Y
Whole	Y	Y	N	N	N	Y	Y	Y	Y
Part	Y	N	Y	Y	Y	Y	N	N	N
Fell Off Something	Y	N	Y	N	Y	Y	N	N	N
In Bag	Y	N	N	N	Y	N	N	Y	N
Colorful	Y	Y	Y	N	Y	N	N	N	Y
Dull	N	N	Y	Y	Y	Y	Y	Y	N
Flexible	Y	N	N	N	Y	Y	N	Y	N
Not Flexible	N	Y	Y	Y	N	Y	Y	Y	Y
Fake (not real)	Y	N	N	N	N	N	N	N	N

Big/Small	Cone > Star > Shell > Bone = SeaW > Rock > Fur = Sand
Heavy/Light	Sand > Shell = Rock > Star = Cone > Bone > SeaW > Fur
Dark/Light(Bright)	Rock > Cone > SeaW > Fur = Sand = Star = Bone > Shell

* Dead Rule -- If Dead/Alive (Living), deduct 1 point for groups and read "dead" as "inorganic"
Y = 1 point if student cross-classifies it this way
Everything is "real" except Seaweed (which is "fake")

Rater Answer Form -- Classification of Materials

Rater Name: ______________________
Rater ID Number: ________ (RAND use only)
AM/PM

Date: July ___, 1993
Starting Time: ___ : ___

Instructions: Circle the number of points awarded for each question.

Student ID Number	Item 2	3	4	5	Item 6	Item 7	Properties	Groups	Boxes	Animals	2
__-__-____ -42	0 1 2	0 1	0 1	0 1	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7	0 1 2	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4 5 6 7 8	0 1
__-__-____ -42	0 1 2	0 1	0 1	0 1	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7	0 1 2	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4 5 6 7 8	0 1
__-__-____ -42	0 1 2	0 1	0 1	0 1	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7	0 1 2	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4 5 6 7 8	0 1
__-__-____ -42	0 1 2	0 1	0 1	0 1	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7	0 1 2	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4 5 6 7 8	0 1
__-__-____ -42	0 1 2	0 1	0 1	0 1	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7	0 1 2	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4 5 6 7 8	0 1
__-__-____ -42	0 1 2	0 1	0 1	0 1	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7	0 1 2	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4 5 6 7 8	0 1
__-__-____ -42	0 1 2	0 1	0 1	0 1	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7	0 1 2	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4 5 6 7 8	0 1
__-__-____ -42	0 1 2	0 1	0 1	0 1	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7	0 1 2	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4 5 6 7 8	0 1
__-__-____ -42	0 1 2	0 1	0 1	0 1	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7	0 1 2	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4 5 6 7 8	0 1
__-__-____ -42	0 1 2	0 1	0 1	0 1	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7	0 1 2	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4 5 6 7 8	0 1
__-__-____ -42	0 1 2	0 1	0 1	0 1	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7	0 1 2	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4 5 6 7 8	0 1
__-__-____ -42	0 1 2	0 1	0 1	0 1	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7	0 1 2	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4 5 6 7 8	0 1
__-__-____ -42	0 1 2	0 1	0 1	0 1	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7	0 1 2	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4 5 6 7 8	0 1
__-__-____ -42	0 1 2	0 1	0 1	0 1	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7	0 1 2	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4 5 6 7 8	0 1
__-__-____ -42	0 1 2	0 1	0 1	0 1	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7	0 1 2	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4 5 6 7 8	0 1
__-__-____ -42	0 1 2	0 1	0 1	0 1	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7	0 1 2	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4 5 6 7 8	0 1
__-__-____ -42	0 1 2	0 1	0 1	0 1	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7	0 1 2	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4 5 6 7 8	0 1
__-__-____ -42	0 1 2	0 1	0 1	0 1	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7	0 1 2	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4 5 6 7 8	0 1
__-__-____ -42	0 1 2	0 1	0 1	0 1	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7	0 1 2	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4 5 6 7 8	0 1
__-__-____ -42	0 1 2	0 1	0 1	0 1	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7	0 1 2	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4 5 6 7 8	0 1

SCORING GUIDE: MATERIALS - CLASSIFICATION - 1994 7th and 8th GRADE

PART 1: Classifying People

QUESTION #2 (p.1)- max. 2 points
1 point for each valid similarity listed by the student, including: sitting, tired, in chairs, hand on knee, wearing shoes. Not acceptable: people, humans, homosapiens, both have eyes (ears, arms, etc.).

Student must clearly indicate two distinct similarities (e.g. "they are both sitting in chairs" would only get one point, but "both sitting, both in chairs" would get 2 points).

QUESTION #3 (p.1)- 1 point

1 point for <u>any valid difference.</u>

For example, <u>award a point</u> if student answers:

Gender
Male/Female
A is male
B is female
Different sex
A is male, B is female
Clothing
Short hair/long hair
Male (a valid characteristic of A)
One is male, one is female
Short pants/long pants
He has a hat (but not: "a hat")
One is wearing a cap, the other isn't

<u>Ways in which student may fail to earn a point:</u>
- Answer that is clearly wrong (e.g., one is adult, one is child)
- Switch characteristics of A and B (e.g., A is female, B is male)
- Illegible response

QUESTION #4 (p.1)- 1 point for No

QUESTION #5 (p.1)- 1 point for Yes

QUESTION #6 (p.2)- Max. 6 points
1 point each for placing the six pictures in the correct boxes.

	C
D, E, G	F, H

Note: Do not award points for A and B.

QUESTION #7 (p.3) - max. 7 points

1 point for each of the seven labels correctly placed.

	Adult	Child
Clothing "season" O.K.	**Adult-Winter**	**Child-Winter**
Summer	**Adult-Summer**	

NOTE: Do not award points for Age, Winter, and Child-Summer.

PART 2: Classifying Materials

COLUMN MATERIALS SCORE (max. 8 pts.)
Count the number of materials that agree with their column labels. If a material is in more than one box, count it only once (but in the box that maximizes the score).

Award no points for materials in a column with a missing or unacceptable label. Unacceptable labels include: things, objects, nature, items, and stuff. If one column has a legitimate label (such as "ocean") and the other column does not (such as "nature") then count all the materials the student properly placed in the ocean column.

If student used a continuous variable for the groups (size, weight, or brightness), refer to the bottom of the "crib" sheet. Check for misclassifications by dividing the order on the sheet at the same point as the student split it. For example, if the student has 3 "dark" objects and 5 "light" ones, the dark objects should match the first 3 on the crib sheet -- rock, cone, and seaweed. If student has 4 dark and 4 light, the 4th dark one could be Fur, Sand, Star or Bone.

> Example: Student says "rock, cone, and fur" are dark and "seaweed, sand, star, bone, and shell" are light. Assign 2 pts for dark column and 4pts for light column for a total of 6.

If the student attempted to complete this part using "people" from the first envelope, assign 0's to the rest of the student's answers.

ROW MATERIALS SCORE (max. 8 pts.). Count the number of materials that agree with their row labels. Follow the same rules as for columns. Obtain a row score for each legitimate group even if the row group label is the same as a column group label.

DEAD RULE: If student labels groups as "dead and living" (or dead and alive), then read the word "dead" as if it were "inorganic"--none of the materials are currently alive (so "alive" means "once living").

BOXES FILLED. Assign a 1 if there is at least one material in each box. Assign a 0 if one or more boxes are empty. If a material is used twice and both times it is the only material in its box, then assign a 0.

INSIDE LABEL SCORE (max. 4 pts.) 1 point for each inside label that signifies membership in two different groups (e.g. "land and rough"). Group names need not agree with their column and row labels, but must be valid in and of themselves. That is, unacceptable labels for rows and columns are not allowed, and the two groups must form a dichotomy.

OUTSIDE LABEL SCORE (max. 4 pts.)

1 point for each of the following:
- Column GROUPs are mutually exclusive
- Row GROUPSs are mutually exclusive
- Column PROPERTY fits its two groups
- Row PROPERTY fits its two groups

Award 1 point for GROUPS if the same names are used for the columns and rows. Award 1 point for PROPERTY if the same one is used twice. Do not award points for property names that do not accurately generalize the groups/variable levels in question: For example, "growth" is not an adequate property for the groups, "forest" and "ocean," but "place" is.

OR RULE: Assign no points for a property if the group label is the same as the property label UNLESS the student uses the word "or," a question mark, or otherwise recognizes a dichotomy between groups in the property label (e.g., 1 point if the groups are "land" and "sea" and the property label is "land or sea", "land or not land", or "land/sea").

TWO-WAY CLASSIFICATION SYSTEM SCORE (max. 4 pts.)

Assign a 0 if one or both of the following occurred:

(1) There is not one properly cross-classified material in at least 3 of the 4 boxes.
(2) Student did not get both points for OUTSIDE column and row labels--OR-- student did not get all 4 points for inside labels.

Otherwise, initially assign a score of 4. Deduct 1 point for each inside label that does not correspond to its outside row and column labels (maximum deduction is 2 points), but close synonyms are OK (such as "big" and "large")--no deduction if inside labels are missing. Deduct 1 point for each material that is improperly classified.

Example 1: 4 boxes missing row and inside labels, fur misclassified

place

land	sea
bone cone	seaweed shell, fur star
rock	sand
3 right	4 right

Column = 7 Row = 0 Boxes = 1 Inside = 0 Outside = 1 System = 0

Example 2: fur in right row, but wrong column; 1 property and all 4 inside missing

place

	land	sea	
alive	bone cone	seaweed shell, fur star	6 right
dead	rock	sand	2 right
	3 right	4 right	

Column = 7 Row = 8 Boxes = 1 Inside = 0 Outside = 3 System = 4-3=1

Example 3: shell misclassified, no inside labels

place

	land	sea	
smooth	bone fur	shell	2 right
rough	rock sand cone	star seaweed	5 right
	5 right	3 right	

Column = 8 Row = 7 Boxes = 1 Inside = 0 Outside = 4 System = 4-1=3

Example 4: sand and rock missing, no inside labels, row property does not fit its groups

		place		
		land	sea	
texture	plant	cone	seaweed	2 right
	animal	fur bone	shell star	4 right
		3 right	3 right	

Column = 6 Row = 6 Boxes = 1 Inside = 0 Outside = 3 System = 4

Example 5: 1 empty box, no inside labels, property labels do not match group

		type		
		bones & fur	no bones or fur	
texture	plant		seaweed cone	2 right
	animal	fur bone	star shell	4 right
		2 right	4 right	

Column = 6 Row = 6 Boxes = 0 Inside = 0 Outside = 2 System = 4

Example 6: No outside labels, 2 misclassified materials

	animals		
sea	seaweed sand SEA PLANTS	starfish shell SEA ANIMALS	3 right
	cone rock LAND PLANTS	fur bone LAND ANIMALS	3 right
	2 right	4 right	

Column = 6 Row = 6 Boxes = 1 Inside = 4 Outside = 0 System = 4-2=2

Example 7: Living/dead and "sea animals" get points

	where found bones & fur	sea things	
living	bone fur LIVING ANIMAL	seaweed star SEA THINGS	4 right
dead	rock, sand cone OTHER	shell SEA ANIMALS	2 right
	2 right	3 right	

Column = 5 Row = 6 Boxes = 1 Inside = 1 Outside = 1 System = 0

Example 7: -2 for inside not matching outside

	habitat land	sea	
alive? yes	bone fur BONES & FUR	seaweed star shell SEA THINGS	5 right
no	cone LAND PLANTS	rocks sand DEAD THINGS	2 right
	3 right	5 right	

Column = 8 Row = 7 Boxes = 1 Inside = 0 Outside = 1 System = 4-2=2

QUESTION #2 (p.5) - 1 point

Student receives 1 point if his or her response is accurate relative to his or her own classification system. Student must identify a box or boxes, or give valid reasons for not placing the object in a box.

GIVE 1 POINT IF THE STUDENT'S EXPLANATION CONTAINS ANY OF THE FOLLOWING:

a) A unique box label that is valid (applies to characteristics of the pencil) - for example, comes from trees

b) Row and column labels that are valid - for example, smooth and not alive

c) Box number AND either row or column label, both of which are valid

d) Student mentions more than one box and gives valid reason for why the object fits into each box - for example, can go in Box 1 (organic/big) or Box 2 (inorganic/big)

e) Student says object does not fit any box and gives valid reason that is consistent with his or her system. The argument that the object doesn't fit because ALL of the cells in the table have some given property is acceptable: For example, "all of the things in my table are natural, and the pencil is man-made."

A student who does not receive a point is most likely to:

a) Provide a box number only, with no reason (needs at least one word)

b) Put object in a box and provide a reason that is inconsistent with his or her labels or classification system

c) Mention a row or column without specifying a particular box or stating why both boxes would be applicable.

If there is an internal conflict (e.g., fits box label but not row and column labels), student gets the benefit of the doubt and receives a point.

CHART FOR SCORING MATERIAL
Objects

GROUPS:	Y SeaW	Z/N Star	D Shell	E Bone	F Fur	X Cone	G Rock	W/M Sand	A Pen
Beach	Y	Y	Y	Y	N	Y	Y	Y	N
Water/Ocean/Sea	Y	Y	Y	Y	N	N	Y	Y	N
Land/Forest/Mountain	N	N	N	Y	Y	Y	Y	Y	Y
Desert	N	N	N	Y	N	N	Y	Y	N
Reproduce	Y	Y	Y	Y	Y	Y	N	N	N
Not Reproduce	N	N	Y	N	Y	N	Y	Y	Y
Living/Once Live	Y	Y	Y	Y	Y	Y	N	N	Y
Growing/Organic	Y	Y	Y	Y	Y	Y	N	N	Y
Not-Living	Y	N	N	N	N	N	Y	Y	Y
In-organic/Mineral	Y	N	N	N	N	N	Y	Y	Y
Dead (see dead rule)	Y	N	N	N	N	N	Y	Y	Y
Natural	Y	Y	Y	Y	Y	Y	Y	Y	N
Man Made	Y	N	N	N	N	N	N	N	Y
Sharp	N	Y	Y	N	N	Y	N	N	N
Blunt	Y	N	N	Y	N	N	Y	N	Y
Prickly	Y	Y	Y	N	N	Y	N	N	N
Rough/Coarse	Y	Y	Y	N	N	Y	N	Y	N
Smooth	Y	N	N	Y	Y	N	Y	Y	Y
Bumpy	Y	Y	Y	Y	N	Y	N	Y	Y
Hard	N	Y	Y	Y	N	Y	Y	Y	Y
Soft	Y	N	N	N	Y	N	N	Y	N
Smelly	Y	Y	Y	Y	Y	Y	N	N	N
Not Smelly	Y	N	Y	N	Y	N	Y	Y	Y
Breakable	Y	Y	Y	Y	N	Y	Y	N	Y
Jagged	Y	Y	Y	N	N	Y	N	N	N
Pointy	Y	Y	Y	N	N	Y	N	N	Y
Curved/Round	Y	N	Y	Y	Y	Y	Y	N	Y
Straight	N	N	N	Y	Y	N	N	N	Y
Long	Y	N	N	Y	Y	N	N	N	Y
Flat	Y	N	N	N	Y	N	Y	Y	N
Animal/Active	N	Y	Y	Y	Y	N	N	N	N
Plant	Y	N	N	N	N	Y	N	N	Y
Human	N	N	N	Y	N	N	N	N	N
Not Human	Y	Y	Y	Y	Y	Y	Y	Y	Y
Whole	Y	Y	N	N	N	Y	Y	Y	Y
Part	Y	N	Y	Y	Y	Y	N	N	N
Fell Off Something	Y	N	Y	N	Y	Y	N	N	N
In Bag	Y	N	N	N	Y	N	N	Y	N
Colorful	Y	Y	Y	N	Y	N	N	N	Y
Dull	N	N	Y	Y	Y	Y	Y	Y	N
Flexible	Y	N	N	N	Y	Y	N	Y	N
Not Flexible	N	Y	Y	Y	N	Y	Y	Y	Y
Fake (not real)	Y	N	N	N	N	N	N	N	N

Big/Small — Cone > Star > Shell > Bone = SeaW > Rock > Fur = Sand
Heavy/Light — Sand > Shell = Rock > Star = Cone > Bone > SeaW > Fur
Dark/Light(Bright) — Rock > Cone > SeaW > Fur = Sand = Star = Bone > Shell

Rater Answer Form - Materials

Rater Name:________________ Date: August____,1994

Rater ID Number:____________ Start Time_____End Time_______

Student ID No.	2	3	4	5	6 (0-6)	7 (0-7)	Col (0-8)	Row (0-8)	Fill Box	Inside	Outside	Systems	Pen
___-___-____-____	0 1 2	0 1	0 1	0 1	____	____	____	____	0 1	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1
___-___-____-____	0 1 2	0 1	0 1	0 1	____	____	____	____	0 1	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1
___-___-____-____	0 1 2	0 1	0 1	0 1	____	____	____	____	0 1	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1
___-___-____-____	0 1 2	0 1	0 1	0 1	____	____	____	____	0 1	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1
___-___-____-____	0 1 2	0 1	0 1	0 1	____	____	____	____	0 1	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1
___-___-____-____	0 1 2	0 1	0 1	0 1	____	____	____	____	0 1	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1
___-___-____-____	0 1 2	0 1	0 1	0 1	____	____	____	____	0 1	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1
___-___-____-____	0 1 2	0 1	0 1	0 1	____	____	____	____	0 1	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1
___-___-____-____	0 1 2	0 1	0 1	0 1	____	____	____	____	0 1	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1
___-___-____-____	0 1 2	0 1	0 1	0 1	____	____	____	____	0 1	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1
___-___-____-____	0 1 2	0 1	0 1	0 1	____	____	____	____	0 1	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1
___-___-____-____	0 1 2	0 1	0 1	0 1	____	____	____	____	0 1	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1
___-___-____-____	0 1 2	0 1	0 1	0 1	____	____	____	____	0 1	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1
___-___-____-____	0 1 2	0 1	0 1	0 1	____	____	____	____	0 1	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1
___-___-____-____	0 1 2	0 1	0 1	0 1	____	____	____	____	0 1	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1
___-___-____-____	0 1 2	0 1	0 1	0 1	____	____	____	____	0 1	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1
___-___-____-____	0 1 2	0 1	0 1	0 1	____	____	____	____	0 1	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1
___-___-____-____	0 1 2	0 1	0 1	0 1	____	____	____	____	0 1	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1
___-___-____-____	0 1 2	0 1	0 1	0 1	____	____	____	____	0 1	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1
___-___-____-____	0 1 2	0 1	0 1	0 1	____	____	____	____	0 1	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1
___-___-____-____	0 1 2	0 1	0 1	0 1	____	____	____	____	0 1	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1
___-___-____-____	0 1 2	0 1	0 1	0 1	____	____	____	____	0 1	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1
___-___-____-____	0 1 2	0 1	0 1	0 1	____	____	____	____	0 1	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1
___-___-____-____	0 1 2	0 1	0 1	0 1	____	____	____	____	0 1	0 1 2 3 4	0 1 2 3 4	0 1 2 3 4	0 1

8. Acids and Bases—Vinegar

The Acids and Bases shell tasks were designed by the University of California, Santa Barbara, and a team from Stanford University and the Far West Laboratory. The tasks were administered to eighth-grade students in 1994.

The shell for these tasks has two parts: (1) performing and interpreting and (2) application. The shell describes a situation in which students must conduct an experiment to solve a problem involving a single independent variable—pH in this case—and apply the results to a practical situation. The shell also describes three versions of the task at different levels of inquiry.

- "Discovery," in which the student must design and perform an experiment.
- "Recipe," in which the student is guided through the experiment.
- "Text," in which the student reads about an experiment conducted by another but does not use any apparatus.

Each group works independently to develop a task. The vinegar task developed by the Stanford University/Far West Laboratory team involves deciding which of three solutions of unknown pH will neutralize a fourth solution of unknown pH. Students have to apply this process to a problem involving a vinegar and an unknown vinegar solution.

A list of the solution concentrations used in the tasks follows the task forms.

The components of the vinegar task will be found on the following pages:

Table 8

Performing and Interpreting Item Shell: Comparative Experiment

STEP	TEXTUAL	RECIPE	DISCOVERY
1	Describe and illustrate equipment.		
2		Provide equipment.	Provide equipment.
3	Describe independent variable A.		
4		Provide independent variable A.	Provide independent variable A.
5			
6			
7		Provide irrelevant variable(s).	Provide irrelevant variable(s).
8	Describe how equipment is used.	Describe how equipment is used.	Describe how equipment is used.
9	Introduce variable names.	Introduce variable names.	Introduce variable names.
10	Include diagrams.	Include diagrams.	Include diagrams.
11		Let students practice with the equipment.	Let students practice with the equipment.
12	Provide a problem involving independent variable A.	Provide a problem involving independent variable A.	Provide a problem involving independent variable A.
13	Include illustration.		
14	Ask students to describe what they will be looking for to solve the problem involving independent variable A.	Ask students to describe what they will be looking for to solve the problem involving independent variable A.	Ask students to describe what they will be looking for to solve the problem involving independent variable A.
15	Provide step by step description of an experiment which solves the problem involving independent variable A.		
16	Provide illustration.		

Table 8

Performing and Interpreting Item Shell: Comparative Experiment (Cont'd.)

17		Provide step-by-step instructions on how to conduct experiment to solve the problem involving independent variable A.	
18			Ask students to conduct an experiment to solve the problem or test hypothesis involving independent variable A.
19		Ask students to take notes as they conduct their experiment.	Ask students to take notes as they conduct their experiment.
20	Describe results.		
21	Ask students to synthesize their results in a *labeled* table / graph / diagram given to them in order to show the relationship between variable A and the outcome.	Ask students to synthesize their results in a *labeled* table / graph / diagram given to them in order to show the relationship between variable A and the outcome.	Ask students to synthesize their results in a *labeled* table / graph / diagram given to them in order to show the relationship between variable A and the outcome.
22			Ask students to write down the steps they took to conduct their experiment.
23	Ask students: to draw a conclusion about the experiment and the relationship found.	Ask students: to draw a conclusion about the experiment and the relationship found.	Ask students: to draw a conclusion about the experiment and the relationship found.
24	Ask students to draw a general conclusion about the relationship involving independent variable A.	Ask students to draw a general conclusion about the relationship involving independent variable A.	Ask students to draw a general conclusion about the relationship involving independent variable A.
25	END	END	END

Table 9

Application Item Shell: Comparative Experiment

STEP	TEXTUAL	RECIPE	DISCOVERY
1	Provide a concrete, meaningful context.	Provide a concrete, meaningful context.	Provide a concrete, meaningful context.
2	Create a scenario which involves the scientific concept of interest.	Create a scenario which involves the scientific concept of interest.	Create a scenario which involves the scientific concept of interest.
3	Provide either a "pure science" problem (e.g., description, measurement classification) or a problem of practical interest (e.g., water pollution) whose solution can be accomplished by using part or all of the knowledge previously taught on the same domain of science knowledge.	Provide either a "pure science" problem (e.g., description, measurement classification) or a problem of practical interest (e.g., water pollution) whose solution can be accomplished by using part or all of the knowledge previously taught on the same domain of science knowledge.	Provide either a "pure science" problem (e.g., description, measurement classification) or a problem of practical interest (e.g., water pollution) whose solution can be accomplished by using part or all of the knowledge previously taught on the same domain of science knowledge.
4	Ask students to suggest possible alternative solutions.	Ask students to suggest possible alternative solutions.	Ask students to suggest possible alternative solutions.
5	END	END	END

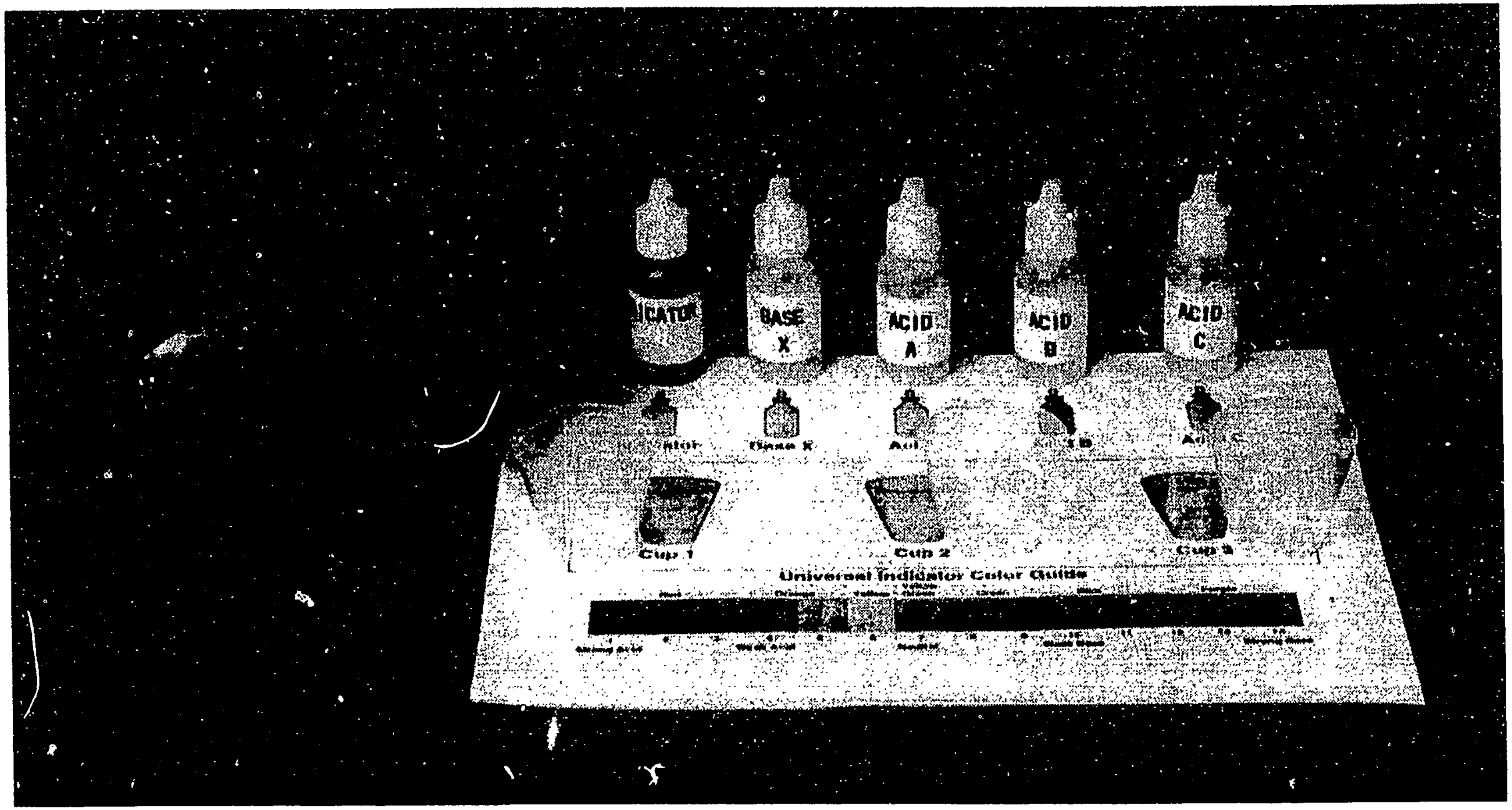


Figure 10—Equipment for Acids and Bases—Vinegar

Task page 1

Name:___________________________ Teacher:__________________________
First Last

Please circle one: Male Female Date of birth:______/______/______
Month Day Year

Acids and Bases - Form D

EQUIPMENT: You will need the following materials. Raise your hand if you are missing any of these materials:

1 bottle labeled INDICATOR
1 bottle labeled BASE X
1 bottle labeled ACID A
1 bottle labeled ACID B
1 bottle labeled ACID C

3 plastic cups
1 placemat
Safety goggles
Paper towels for spills

Every solution is an acid, a base, or neutral. Acids and bases are chemical opposites of each other. Solutions that are neither acids or bases are neutral. Chemists use numbers to indicate the strengths of acids and bases. The numbers go from 1 to 14. Strong acids have low numbers and strong bases have high numbers. Neutral solutions are in the middle.

Chemists use a solution called Universal Indicator to identify acids and bases. Universal Indicator changes color when mixed with an acid or base. The Universal Indicator Color Guide shows that Universal Indicator turns red when it is added to a strong acid, it turns purple when it is added to a strong base, and it turns yellowish-green when it is added to a neutral solution.

UNIVERSAL INDICATOR COLOR GUIDE

Strong Acid			Weak Acid			Neutral			Weak Base				
1	2	3	4	5	6	7	8	9	10	11	12	13	14
RED—			—RED	ORANGE	YELLOW	YELLOWISH GREEN	GREEN	BLUE		PURPLE—			—PURPLE

All acids in the range of 1 to 4 turn the indicator red. All bases in the range of 11 to 14 turn the indicator purple. Today you will learn how to test if one acid is stronger than another even if they both turn the indicator the same color.

PART 1: READING THE SCALE

1a. Which acid is stronger -- one that turns Universal Indicator orange or one that turns Universal Indicator yellow?

____

1b. Which base is stronger -- one that turns Universal Indicator blue or one that turns Universal Indicator purple?

____

GO TO NEXT PAGE

Task page 2

PART 2: NEUTRALIZING ACIDS AND BASES

Read the directions carefully and follow all the steps. Then answer the questions clearly and completely.

The color of the Universal Indicator can be used to show what happens when an acid and a base are mixed. If you mix the right amounts of an acid and a base you can obtain a neutral solution (yellowish-green color). Because the solution becomes neutral, chemists say acids and bases can neutralize one another.

To see how this is done, follow these steps

Step 1: Gently squeeze 7 drops of Indicator into Cup 1.

Step 2: Add 7 drops of Base X to the solution in Cup 1. Gently swirl the cup to mix the solutions, observe the color, and record the color **on the line for 0 drops** in Table 1.

Step 3: Add 1 drop of Acid A to the solution in Cup 1. Gently swirl the cup to mix in the acid, observe the color, and record the color **on the line for 1 drop** in Table 1.

Step 4: Continue adding 1 drop of Acid A at a time to the solution until you have added 8 drops. After each drop, swirl the solution, observe the color, and record the color in Table 1.

Table 1

DROPS OF ACID A ADDED	COLOR OF SOLUTION
0 (Base X + Indicator only)	
1	
2	
3	
4	
5	
6	
7	
8	

GO TO NEXT PAGE

Task page 3

2a. Look at the sequence of colors in Table 1. Compare it to the Universal Indicator Color Guide on your placemat. How did the solution in Cup 1 change as drops of Acid A were added?

2b. How many drops of Acid A did it take to turn the solution yellow? ________

2c. Suppose you conducted the same experiment with a stronger acid and recorded the colors in a table. How would the results in this new table be the same or different than those in Table 1? Explain your answer.

GO TO NEXT PAGE

Task page 4

PART 3: TESTING ACID STRENGTH

In Part 1 you learned how to neutralize a base with an acid. Now you need to use this procedure to find out **WHICH ACID IS STRONGER - ACID B OR ACID C.**

You will NOT be given directions to follow to answer this question. Instead, **use the materials you have been given to plan your own experiment to tell which is stronger -- Acid B or Acid C.**

3a. Now carry out your experiment. Use the space below to make a table or chart to record the results and then fill it in as you work.

Task page 5

Table 2

DROPS OF ACID ADDED	COLOR OF SOLUTION -- USING ACID B	COLOR OF SOLUTION -- USING ACID C
0 (Base X + Indicator only)		
1		
2		
3		
4		
5		
6		
7		
8		

GO TO NEXT PAGE

Task page 6

3b. Write down and number the steps you followed as you conducted your experiment. Be specific, so another student in your class could conduct the experiment exactly as you did. For example, if you mixed solutions together, tell how much of each solution you used.

GO TO NEXT PAGE

Task page 7

PART 4: ANALYZING RESULTS

4a. Fill in the following blank spaces based on the results of your experiment.

_____ drops of Base X + _____ drops of Acid B = neutral solution

_____ drops of Base X + _____ drops of Acid C = neutral solution

4b. Which acid is stronger -- Acid B or Acid C?

____

4c. How do you know this?

____

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____

4d. Vinegar is a household acid that can be used in cooking. Most vinegars in the United States are diluted to make a 5% solution, but vinegars in Europe are made into a slightly stronger 6% solution. Chef Andrea uses both types of vinegars in her restaurant. There are three bottles of vinegar on her shelf. One is marked 5% and one is marked 6%. The label has fallen off the third bottle of vinegar. She wants to know if the third bottle is 5% or 6% vinegar. How could she use the equipment you used to figure out the strength of the vinegar in the third bottle?

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GO TO NEXT PAGE

Task page 8

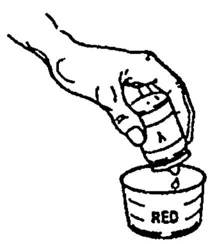
4e. Sally has a bottle of Base Y and a bottle of Base Z. To find out which base is stronger:

• she puts 7 drops of Base Y, 7 drops of Indicator, and 10 drops of Acid B into a cup. The solution in the cup turns red.

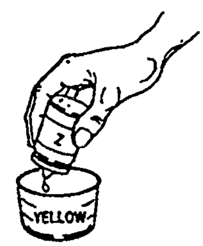
• Into a new cup she puts 7 drops of Base Z, 7 drops of Indicator, and 10 drops of Acid B. The solution in this cup turns yellow.

Which base is stronger--Base Y or Base Z?

____



Base Y +
Indicator + Acid B



Base Z +
Indicator + Acid B

4f. How do you know this?

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Task page 1

Name:______________________ Teacher:______________________
First Last

Please circle one: Male Female Date of birth:_______/_______/_______
Month Day Year

Acids and Bases - Form R

EQUIPMENT: You will need the following materials. Raise your hand if you are missing any of these materials:

1 bottle labeled INDICATOR
1 bottle labeled BASE X
1 bottle labeled ACID A
1 bottle labeled ACID B
1 bottle labeled ACID C
3 plastic cups
1 placemat
Safety goggles
Paper towels for spills

Every solution is an acid, a base, or neutral. Acids and bases are chemical opposites of each other. Solutions that are neither acids or bases are neutral. Chemists use numbers to indicate the strengths of acids and bases. The numbers go from 1 to 14. Strong acids have low numbers and strong bases have high numbers. Neutral solutions are in the middle.

Chemists use a solution called Universal Indicator to identify acids and bases. Universal Indicator changes color when mixed with an acid or base. The Universal Indicator Color Guide shows that Universal Indicator turns red when it is added to a strong acid, it turns purple when it is added to a strong base, and it turns yellowish-green when it is added to a neutral solution.

UNIVERSAL INDICATOR COLOR GUIDE

Strong Acid			Weak Acid			Neutral			Weak Base				Strong Base
1	2	3	4	5	6	7	8	9	10	11	12	13	14
RED——			——RED	ORANGE	YELLOW	YELLOWISH GREEN	GREEN	BLUE		PURPLE——			——PURPLE

All acids in the range of 1 to 4 turn the indicator red. All bases in the range of 11 to 14 turn the indicator purple. Today you will learn how to test if one acid is stronger than another even if they both turn the indicator the same color.

PART 1: READING THE SCALE

1a. Which acid is stronger -- one that turns Universal Indicator orange or one that turns Universal Indicator yellow?

____

1b. Which base is stronger -- one that turns Universal Indicator blue or one that turns Universal Indicator purple?

____

GO TO NEXT PAGE

Task page 2

PART 2: NEUTRALIZING ACIDS AND BASES

Read the directions carefully and follow all the steps. Then answer the questions clearly and completely.

The color of the Universal Indicator can be used to show what happens when an acid and a base are mixed. If you mix the right amounts of an acid and a base you can obtain a neutral solution (yellowish-green color). Because the solution becomes neutral, chemists say acids and bases can neutralize one another.

To see how this is done, follow these steps

Step 1: Gently squeeze 7 drops of Indicator into Cup 1.

Step 2: Add 7 drops of Base X to the solution in Cup 1. Gently swirl the cup to mix the solutions, observe the color, and record the color **on the line for 0 drops** in Table 1.

Step 3: Add 1 drop of Acid A to the solution. Gently swirl the cup to mix in the acid, observe the color, and record the color **on the line for 1 drop** in Table 1.

Step 4: Continue adding 1 drop of Acid A at a time to the solution until you have added 8 drops. After each drop, swirl the solution, observe the color, and record it in Table 1.

Table 1

DROPS OF ACID A ADDED	COLOR OF SOLUTION
0 (Base X + Indicator only)	
1	
2	
3	
4	
5	
6	
7	
8	

GO TO NEXT PAGE

Task page 3

2a. Look at the sequence of colors in Table 1. Compare it to the Universal Indicator Color Guide on the placemat. How did the solution in Cup 1 change as drops of Acid A were added?

____

____

____

____

____

____

____

____

2b. How many drops of Acid A did it take to turn the solution yellow?________

2c. Suppose you conducted the same experiment with a stronger acid and recorded the colors in a table. How would the results in this new table be the same or different than those in Table 1? Explain your answer.

____

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GO TO NEXT PAGE

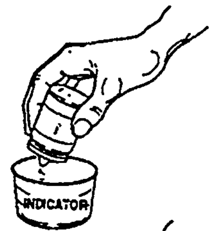
Task page 4

PART 3: TESTING ACID STRENGTH

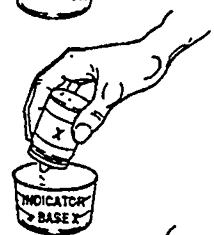
In Part 1 you learned a technique for neutralizing a base with an acid. Now you need to add drops of acid to the base in separate cups to find out WHICH ACID IS STRONGER - ACID B OR ACID C.

Use **Cup 2** and **Acid B**, as follows:

Step 1: Put 7 drops of Indicator into Cup 2.



Step 2: Add 7 drops of Base X to the solution in Cup 2, observe the color, and write it in Table 2.

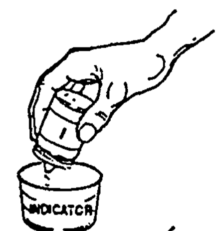


Step 3: Add 1 drop of Acid B, mix the solution, and write the color in Table 2.

Step 4: Continue adding Acid B, drop by drop, until you have added 8 drops. After each drop mix the solution, observe the color, and write it in Table 2.

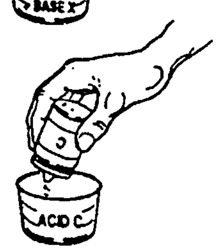
Use **Cup 3** and **Acid C**, as follows:

Step 5: Put 7 drops of Indicator into Cup 3.



Step 6: Add 7 drops of Base X to the solution in Cup 3, observe the color, and write it in Table 2.

Step 7: Add 1 drop of Acid C, mix the solution, and write the color in Table 2.



Step 8: Continue adding Acid C, drop by drop, until you have added 8 drops. After each drop mix the solution, observe the color, and write it in Table 2.

Task page 5

Table 2

DROPS OF ACID ADDED	COLOR OF SOLUTION -- USING ACID B	COLOR OF SOLUTION -- USING ACID C
0 (Base X + Indicator only)		
1		
2		
3		
4		
5		
6		
7		
8		

GO TO NEXT PAGE

Task page 6

PART 4: ANALYZING RESULTS

4a. Fill in the following blank spaces based on the results of your experiment.

_____ drops of Base X + _____ drops of Acid B = neutral solution

_____ drops of Base X + _____ drops of Acid C = neutral solution

4b. Which acid is stronger -- Acid B or Acid C?

____

4c. How do you know this?

4d. Vinegar is a household acid that can be used in cooking. Most vinegars in the United States are diluted to make a 5% solution, but vinegars in Europe are made into a slightly stronger 6% solution. Chef Andrea uses both types of vinegars in her restaurant. There are three bottles of vinegar on her shelf. One is marked 5% and one is marked 6%. The label has fallen off the third bottle of vinegar. She wants to know if the third bottle is 5% or 6% vinegar. How could she use the equipment you used to figure out the strength of the vinegar in the third bottle?

Task page 7

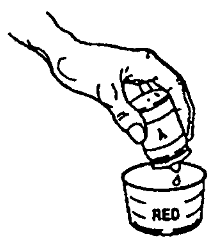
4e. Sally has a bottle of Base Y and a bottle of Base Z. To find out which base is stronger:

- She puts 7 drops of Base Y, 7 drops of Indicator, and 10 drops of Acid B into a cup. The solution in the cup turns red.

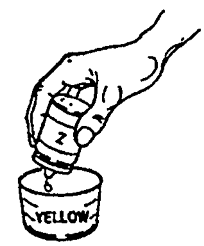
- Into a new cup she puts 7 drops of Base Z, 7 drops of Indicator, and 10 drops of Acid B. The solution in this cup turns yellow.

Which base is stronger--Base Y or Base Z?

____



Base Y +
Indicator + Acid B



Base Z +
Indicator + Acid B

4f. How do you know this?

____

____

____

____

____

Task page 1

Name:__________________________ Teacher:__________________________
First Last

Please circle one: Male Female Date of birth:______/______/______
Month Day Year

Acids and Bases - Form T

Every solution is an acid, a base, or neutral. Acids and bases are chemical opposites of each other. Solutions that are neither acids or bases are neutral. Chemists use numbers to indicate the strengths of acids and bases. The numbers go from 1 to 14. Strong acids have low numbers and strong bases have high numbers. Neutral solutions are in the middle.

Chemists use a solution called Universal Indicator to identify acids and bases. Universal Indicator changes color when mixed with an acid or base. The Universal Indicator Color Guide shows that Universal Indicator turns red when it is added to a strong acid, it turns purple when it is added to a strong base, and it turns yellowish-green when it is added to a neutral solution.

UNIVERSAL INDICATOR COLOR GUIDE

Strong Acid			Weak Acid			Neutral			Weak Base			Strong Base	
1	2	3	4	5	6	7	8	9	10	11	12	13	14
RED	----------	----------	RED	ORANGE	YELLOW	YELLOWISH GREEN	GREEN	BLUE		PURPLE	----------	----------	PURPLE

All acids in the range of 1 to 4 turn the indicator red. All bases in the range of 11 to 14 turn the indicator purple. Today you will learn how to test if one acid is stronger than another even if they both turn the indicator the same color.

PART 1: READING THE SCALE

1a. Which acid is stronger -- one that turns Universal Indicator orange or one that turns Universal Indicator yellow?

____

1b. Which base is stronger -- one that turns Universal Indicator blue or one that turns Universal Indicator purple?

____

PART 2: NEUTRALIZING ACIDS AND BASES

An eighth grade student named Tony conducted an experiment using the following equipment:

1 bottle labeled INDICATOR
1 bottle labeled BASE X
3 plastic cups

1 bottle labeled ACID A
1 bottle labeled ACID B
1 bottle labeled ACID C

GO TO NEXT PAGE

Task page 2

Read Tony's experiment carefully. Then answer the questions clearly and completely.

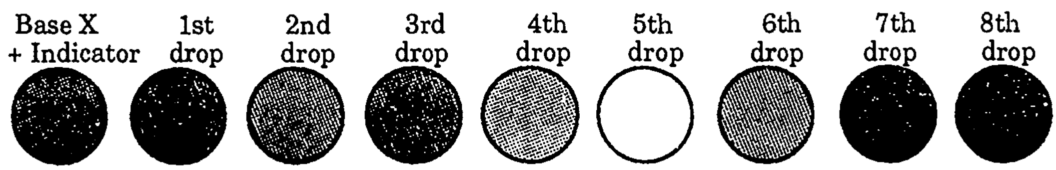
The color of the Universal Indicator can be used to show what happens when an acid and a base are mixed. If you mix the right amounts of an acid and a base you can obtain a neutral solution (yellowish-green color). Because the solution becomes neutral, chemists say acids and bases can <u>neutralize</u> one another.

To see how this is done, Tony followed these steps

Step 1: Tony put 7 drops of Indicator into Cup 1. The color was yellowish-green.

Step 2: Tony added 7 drops of Base X to the solution in Cup 1. The color turned purple. He wrote the color in Table 1.

Step 3: Tony added 1 drop of Acid A, mixed the solution, observed the color, and wrote it in Table 1. He continued adding Acid A, drop by drop, until he had added 8 drops. After each drop he mixed the solution, observed the color, and wrote it in the table. Here is the color he saw after each drop:



Here is the information Tony wrote in the table:

Table 1

DROPS OF ACID A ADDED	COLOR OF SOLUTION
0 (Base X + Indicator only)	Purple
1	Blue
2	Greenish-blue
3	Green
4	Yellowish-green
5	Yellow
6	Orange
7	Red
8	Red

GO TO NEXT PAGE

Task page 3

2a. Look at the sequence of colors in Table 1. Compare it to the Universal Indicator Color Guide on the first page. How did the solution in Cup 1 change as drops of Acid A were added?

2b. How many drops of Acid A did it take to turn the solution yellow?

2c. Suppose you conducted the same experiment with a stronger acid and recorded the colors in a table. How would the results in this new table be the same or different than those in Table 1? Explain your answer.

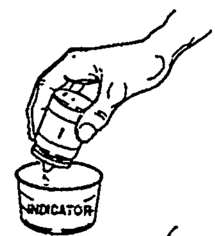
GO TO NEXT PAGE

PART 3: TESTING ACID STRENGTH

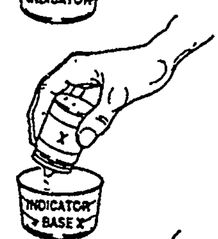
In Part 1 Tony learned a technique for neutralizing a base with an acid. Next he did an experiment to find out **WHICH ACID IS STRONGER - ACID B OR ACID C.**

Task page 4

First, he used Cup 2 and Acid B, as follows:

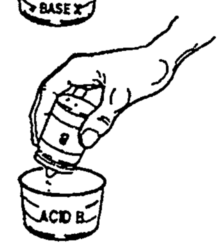


Step 1: Tony put 7 drops of Indicator into Cup 2.



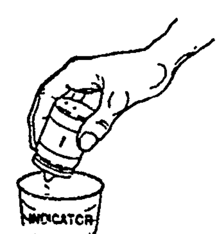
Step 2: Tony added 7 drops of Base X to the solution in Cup 2, observed the color, and wrote it in Table 2.

Step 3: Tony added 1 drop of Acid B, mixed the solution, and wrote the color in Table 2.



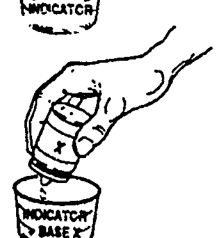
Step 4: He continued adding Acid B, drop by drop, until he had added 8 drops. After each drop he mixed the solution, observed the color, and wrote it in Table 2.

Then, he used Cup 3 and Acid C, as follows:

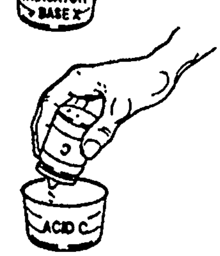


Step 5: Tony put 7 drops of Indicator into Cup 3.

Step 6: Tony added 7 drops of Base X into the solution in Cup 3, observed the color, and wrote it in Table 2.



Step 7: Tony added 1 drop of Acid C, mixed the solution, and wrote the color in Table 2.



Step 8: He continued adding Acid C, drop by drop, until he had added 8 drops. After each drop he mixed the solution, observed the color, and wrote it in Table 2.

Task page 5

Here are the results of Tony's experiment:

Table 2

DROPS OF ACID ADDED	COLOR OF SOLUTION -- USING ACID B	COLOR OF SOLUTION -- USING ACID C
Base X + Indicator only	Purple	Purple
1	Blue	Bluish-purple
2	Yellowish-green	Blue
3	Orange	Bluish-green
4	Orange-red	Green
5	Red	Green
6	Red	Yellowish-green
7	Red	Yellow
8	Red	Orange

3a. Which acid, B or C, took the most drops to turn the solution orange?

____

3b. About how many drops of **Acid C** would it take to turn the solution red?

____

3c. Explain why you chose this number.

____

____

____

GO TO NEXT PAGE

Task page 6

PART 4: ANALYZING RESULTS

4a. Fill in the following blank spaces based on the results of Tony's experiment.

_____ drops of Base X + _____ drops of Acid B = neutral solution

_____ drops of Base X + _____ drops of Acid C = neutral solution

4b. Which acid is stronger -- Acid B or Acid C?

____

4c. How do you know this?

____

____

____

____

____

____

4d. Vinegar is a household acid that can be used in cooking. Most vinegars in the United States are diluted to make a 5% solution, but vinegars in Europe are made into a slightly stronger 6% solution. Chef Andrea uses both types of vinegars in her restaurant. There are three bottles of vinegar on her shelf. One is marked 5% and one is marked 6%. The label has fallen off the third bottle of vinegar. She wants to know if the third bottle is 5% or 6% vinegar. How could she use the equipment Tony used to figure out the strength of the vinegar in the third bottle?

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GO TO NEXT PAGE

Task page 7

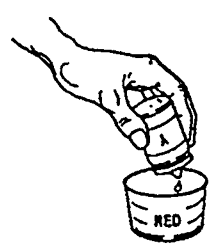
4e. Sally has a bottle of Base Y and a bottle of Base Z. To find out which base is stronger:

- She puts 7 drops of Base Y, 7 drops of Indicator, and 10 drops of Acid B into a cup. The solution in the cup turns red.

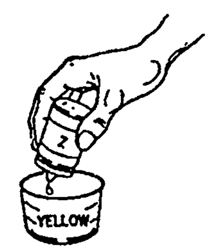
- Into a new cup she puts 7 drops of Base Z, 7 drops of Indicator, and 10 drops of Acid B. The solution in this cup turns yellow.

Which base is stronger--Base Y or Base Z?

____



Base Y +
Indicator + Acid B



Base Z +
Indicator + Acid B

4f. How do you know this?

____

____

____

____

____

____

SOLUTION CONCENTRATIONS FOR ACIDS AND BASES VINEGAR

Indicator	50% Lab-Aids® Universal Indicator and 50% deionized water
Base X	1.5 ml 5% ammonia and 8.5 ml deionized water
Acid A	4 ml 5% vinegar and 6 ml deionized water
Acid B	5% vinegar solution
Acid C	4 ml 5% vinegar and 6 ml deionized water

VINEGAR DISCOVERY SCORING RUBRIC

PART 1

1a 1 pt Orange

1b 1 pt Purple

PART 2

Table 1 pt Color change in right direction: Blue - Green -Yellow - Orange. (No point for interval reversals of color, e.g Yellow to Green, unless correct pH sequence shown: pH takes precedence over color. Hyphenated color reversals are OK, e.g. blue-green is the same as green-blue: May be missing only 1 entry at most to receive a point). **3 color rule** if student puts down 3 colors in one entry of table--if done once ignore if done twice no point for correct color change.

1 pt Change from base to neutral occurs at 5-7 drops of acid (color change to yellowish-green or from green to yellow/orange)
3 color rule: an entry with 3 colors cannot be considered the point where the base changed to neutral.

2a 1 pt Color change in right direction: Purple to Blue to Green to Yellow to Orange to Red; Purple to Red; right to left on color guide; dark to light to dark/ got lighter then darker; base to acid colors; colors go in opposite order on universal color guide.
Answers must include a startpoint color and an endpoint. (Not acceptable: Colors became lighter, darker, brighter, bolder, different, light to dark, or dark to light).

1 pt Acidity change: base to acid; high to low pH; right to left on color guide; or solution neutralized and then turned to acid. Answers must include a startpoint (pH or base) and an endpoint (pH or acid).

Note on 2a: If startpoint and endpoint are in different measures but are correct (e.g. solution went from Purple to Acid) give 1 point overall for 2a..

2b DO NOT SCORE (the solution may go from yellowish-green to orange with a single drop)

2c 1 pt Colors change faster; get to a specific color faster or with fewer drops; got to neutral faster or with fewer drops; final color would be closer to red; fewer in between colors or skipped colors. (Not acceptable: colors are different, brighter, lighter, darker, more intense, bolder; solutions are stronger or weaker; less colors or fewer colors).

1 pt Solutions would be more acidic; become acidic faster; the base will be neutralized quicker/with fewer drops of acid; solution balanced out quicker; end up with a strong or stronger acid.

PART 3

3a 1 pt Clearly labeled place for recording data for Acids B & C. (Must say B & C: cannot say 1 & 2 or other labels).

1 pt Identifies number of drops for each Acid used or to be used. (Requires 2 tables but they do not have to be labeled Acid B & C respectively).

1 pt Recorded color sequence for Acid B that goes from Base to Acid, e.g. Blue - Green - Yellow - Orange (May be missing only 1 entry at most to receive a point: May use pH numbers instead of colors. No point if obvious no Base X used, e.g. first color shows an acid solution: No point if reversed color interval). Use 3 color rule from Part 2.

1 pt Recorded color sequence for Acid C that goes from Base to Acid, e.g. Blue - Green - Yellow - Orange (May be missing only 1 entry at most to receive a point: May use pH numbers instead of colors. No point if clear no Base X used, e.g. first color shows an acid solution: No point if reversed color interval). Use 3 color rule from Part 2.

1 pt Color change to neutral (or from base to acid) occurs more quickly for Acid B
(No points if Acid A used or if clear no Base X used).

Addressing Unlabeled or Wrongly Labeled Tables or Charts

1. If tables labeled for Acids A and (B or C) then two point maximum: 1 point for number of drops and 1 point for correct color sequence for Acid B or C.

2. If 1 table labeled correctly (Acid B or C) and 1 table unlabeled then assume unlabeled table is labeled correctly with missing Acid. But penalty of 1 point: do not give point for clearly labeled place.

3. If both tables unlabeled or 1 table labeled Acid A and one table blank then 1 point maximum: 1 point possible for identifies number of drops.

Special Case for 3a

5 pt A bar chart, correctly labeled for the two acids and drops used, that shows how many drops to a specific color or pH.

3b 1 pt Use a clean cup (if mentioned at least once: must specifically say "clean cup", "new cup" or "cup 2"

1 pt Fixed amount of Base X used

1 pt Indicator used

1 pt Same amount of acid added at a time (e.g 1 drop).

1 pt Swirl solution in cup (if mentioned at least once: can also say mix, stir, or shake).

1 pt Color recorded after each drop.
In place of color, student can also say pH, data, results, findings, or information.
In place of recorded, student can also say written or noted (not acceptable is any verb that does not imply writing results down such as observed or watched).

1 pt Same procedure done for both Acid B & C (Does not need to be correct procedure to earn this point).

1 pt Compare results for the two acids; note difference in outcomes such as number of drops of acid to get to neutral or a specific color or a specific pH level or note speed of color change or shift in pH level; note which acid is stronger

NOTE: Scorers cannot refer back to 3a when scoring 3b unless student refers them back to 3a. If no answer in 3b but student has written one in 3a, student must tell reader to refer back to 3a to get points for 3b.

Special Case for 3b

4 pt Answer says to "repeat the same steps done with Acid A in Part 2 but using Acids B & C". Award 4 points overall for 3b.
(Give credit only if 2 points earned for Table 1).

If student has developed any other experiment that makes sense, give 4 points.

1 pt Compare results for the two acids; note difference in outcomes such as number of drops of acid to get to neutral or a specific color or a specific pH level or note speed of color change or shift in pH level; note which acid is stronger

PART 4 (4d to 4f are to be scored separately)

4a

Line 1

1 pt Amount of Base X equals 7 or amount noted in 3a or 3b. (What student has written in 3a or 3b takes precedence: if differs from 7 then 7 is not acceptable).

1 pt Number of drops of Acid B noted in 3a or 3b that made solution neutral (If neutral, yellowish green, not obtained in experiment, OK to interpolate number of drops or use number of drops that get to first acidic color, e.g. yellow or orange. Use first entry on table where change from base to acid occurs).

Line 2

1 pt Amount of Base X equals 7 or amount noted in 3a or 3b. (What student has written in 3a or 3b takes precedence: if differs from 7 then 7 is not acceptable).

1 pt Number of drops of Acid C noted in 3a or 3b that made solution neutral (If neutral, yellowish green, not obtained in experiment, OK to interpolate number of drops or use number of drops that get to first acidic color, e.g. yellow or orange. Use first entry on table where change from base to acid occurs).

4b 1 pt Acid B
(Must get 4b correct to receive points for 4c)

4c 1 pt Fewer drops of Acid B to get to neutral or to get to a specific color or to go from 1 color to another; Acid B changes colors more quickly; Acid B worked faster; Acid B got to a stronger acid color.

VINEGAR RECIPE SCORING RUBRIC

PART 1

1a	1 pt	Orange
1b	1 pt	Purple

PART 2

Table 1 — 1 pt — Color change in right direction: Blue - Green - Yellow - Orange
(No point for interval reversals of color, e.g Yellow to Green, unless correct pH sequence shown: pH takes precedence over color. Hyphenated color reversals are OK, e.g. blue-green is the same as green-blue: May be missing only 1 entry at most to receive a point).
3 color rule if student puts down 3 colors in one entry of table--if done once ignore if done twice no point for correct color change.

1 pt — Change from base to neutral occurs at 5-7 drops of acid (color change to yellowish-green or from green to yellow/orange)
3 color rule: an entry with 3 colors cannot be considered the point where the base changed to neutral.

2a — 1 pt — Color change in right direction: Purple to Blue to Green to Yellow to Orange to Red; Purple to Red; right to left on color guide; dark to light to dark/ got lighter then darker; base to acid colors; colors go in opposite order on universal color guide.
Answers must include a startpoint color and an endpoint. (Not acceptable: Colors became lighter, darker, brighter, bolder, different, light to dark, or dark to light).

1 pt — Acidity change: base to acid; high to low pH; right to left on color guide; or solution neutralized and then turned to acid. Answers must include a startpoint (pH or base) and an endpoint (pH or acid).

Note on 2a: If startpoint and endpoint are in different measures but are correct (e.g. solution went from Purple to Acid) give 1 point overall for 2a..

2b DO NOT SCORE (the solution may go from yellowish-green to orange with a single drop)

2c 1 pt Colors change faster; get to a specific color faster or with fewer drops; got to neutral faster or with fewer drops; final color would be closer to red; fewer in between colors or skipped colors.
(Not acceptable: colors are different, brighter, lighter, darker, more intense, bolder; solutions are stronger or weaker; less colors or fewer colors).

1 pt Solutions would be more acidic; become acidic faster; the base will be neutralized quicker/with fewer drops of acid; solution balanced out quicker; end up with a strong or stronger acid.

PART 3 (The following pertain to Table 2; apply the 3 color rule from Part 2)

A. Acid B

1 pt Color sequence for Acid B goes from Base to Acid: Blue - Green - Yellow - Orange (May be missing only 1 entry at most to receive a point).

1 pt 2, 3 or 4 drops of Acid B makes solution neutral (yellowish-green or change from green to yellow/orange).

B. Acid C

1 pt Color sequence for Acid C goes from Base to Acid: Blue - Green - Yellow - Orange (May be missing only 1 entry at most to receive a point).

1 pt 5, 6 or 7 drops of Acid C makes solution neutral (yellowish-green or change from green to yellow/orange).

C. Comparing Acid B & Acid C

1 pt Color change to neutral occurs more quickly for Acid B

PART 4 (4d to 4f are to be scored separately)

4a

Line 1

1 pt	7 drops of Base X
1 pt	Number of drops of Acid B in Table 2 at neutral (If neutral, yellowish green, not obtained in experiment, OK to interpolate number of drops or use number of drops that get to first acidic color, e.g. yellow. Use first entry on table where change from base to acid occurs).

Line 2

1 pt	7 drops of Base X
1 pt	Number of drops of Acid C in Table 2 at neutral (If neutral, yellowish green, not obtained in experiment, OK to interpolate number of drops or use number of drops that get to first acidic color, e.g. yellow. Use first entry on table where change from base to acid occurs).

4b	1 pt	Acid B (**Must get 4b correct to receive points for 4c**)
4c	1 pt	Fewer drops of Acid B to get to neutral or to get to a specific color or to go from 1 color to another; Acid B changes colors more quickly; Acid B worked faster; Acid B got to a stronger acid color.

VINEGAR TEXT SCORING RUBRIC

PART 1

1a	1 pt	Orange
1b	1 pt	Purple

PART 2

2a	1 pt	Color change in right direction: Purple to Blue to Green to Yellow to Orange to Red; Purple to Red; right to left on color guide; dark to light to dark/ got lighter then darker; base to acid colors; colors go in opposite order on universal color guide. Answers must include a startpoint color and an endpoint. (Not acceptable: Colors became lighter, darker, brighter, bolder, different, light to dark, or dark to light).
	1 pt	Acidity change: base to acid; high to low pH; right to left on color guide; or solution neutralized and then turned to acid. Answers must include a startpoint (pH or base) and an endpoint (pH or acid).

Note on 2a: If startpoint and endpoint are in different measures but are correct (e.g. solution went from Purple to Acid) give 1 point overall for 2a..

2b	1 pt	5
2c	1 pt	Colors change faster; get to a specific color faster or with fewer drops; got to neutral faster or with fewer drops; final color would be closer to red; fewer in between colors or skipped colors. (Not acceptable: colors are different, brighter, lighter, darker, more intense, bolder; solutions are stronger or weaker; less colors or fewer colors).
	1 pt	Solutions would be more acidic; become acidic faster; the base will be neutralized quicker/with fewer drops of acid; solution balanced out quicker; end up with a strong or stronger acid.

PART 3

3a	1 pt	Acid C
3b	1 pt	9 - 20 drops or 1-12 drops more (must say more) (**Must get 3b correct to receive points for 3c**)
3c	1 pt	It takes more drop(s) to go from orange to red; 9 is orange red and 10 is red; the student bases their answer on a correct proportion.
	1 pt	It takes more drops using Acid C to get the same outcome; Acid C causes a slower change than Acid B; Acid C is weaker or has higher pH than Acid B

PART 4 (4d to 4f are to be scored separately)

4a		
	Line 1	
	1 pt	7 drops of Base X
	1 pt	2 drops of Acid B
	Line 2	
	1 pt	7 drops of Base X
	1 pt	6 drops of Acid C
4b	1 pt	Acid B (**Must get 4b correct to receive points for 4c**)
4c	1 pt	Fewer drops of Acid B to get to neutral or to get to a specific color or to go from 1 color to another; Acid B changes colors more quickly; Acid B worked faster; Acid B got to a stronger acid color.

VINEGAR 4D, 4E AND 4F SCORING RUBRIC: All VERSIONS

4di 1 pt 3 vinegars used (may state 3 vinegars used or say each, every, all vinegars): or
2 vinegars (including the unknown) used. The unknown may be called the mystery vinegar or the third bottle.

4dii These 2 points can be given regardless of validity of experiment

1 pt Indicator used

1 pt Base X used

4diii These 2 points are only given if scorer can infer that the unknown vinegar is used. Inference rule is that student says more than 1 vinegar is being tested but does not indicate that only the 2 known vinegars are being tested.

Also, these 2 points can be given (if the above inference met) if the student sets up a reversed experiment using a set amount of the vinegars and monitors drops of Base X added to the vinegars. Substitute vinegar for Base X and Base X for vinegar in the rubric to score this experiment for the following 2 points.

1 pt Amount of Base X held constant in all tests

1 pt The amount of vinegar added is monitored (Must use Base X to get this point)

4div 1 pt A comparison of the results from the different vinegars tested is made. The student must either say:

1. Compare the results of all three vinegars, or
2. Compare the results of the unknown vinegar (may be inferred unknown--see 4diii) with a specific known vinegar (either the 5% or the 6% vinegar). (The comparison must be of the color change to receive this point).

Special Case for 4d (4 points possible):

3 pt The answers says to follow the same steps as in Part 3 and notes that at least 2 vinegars are used (including the unknown vinegar) in place of Acids A & B.

(Must get all 5 points on 3a in Recipe or Discovery to get these points. If Text version can get these points by referring to Tony's experiment as long as use of vinegar discussed).

1 pt A comparison of the results from the different vinegars tested is made (see 4div on the comparison).

4e 1 pt Base Z or yellow or the illustration of Base Z is circled.
(Give point if 4e left blank but 4f has Base Z).

4f 1 pt Yellow is less acidic or weaker than red;
Red is more acidic or stronger than yellow.
Takes more drops of Acid to make Base Z acidic; it is less acidic after the same number of drops added; harder to make Base Z an acid; less of a color change means a stronger base; Base Z did not weaken as much as Base Y: the higher pH number is a sign that Base Z is stronger: the resulting solution is closer to a base.
(Must get a point for 4e to receive this point)

1 pt Number of drops of the bases and acids held constant for both tests (only need to be said once).

Rater Answer Form - Vinegar Discovery

Rater Name:________________ Date: August____,1994

Rater ID Number:____________ Time: Start________ End________

Student ID No.	PART 1		PART 2			PART 3		PART 4		
	A	B	TAB1	A	C	3A (0-5 pt)	3B (0-8 pt)	A	B	C
____-____-____-41	0 1	0 1	0 1 2	0 1 2	0 1 2	0 1 2 3 4 5	0 1 2 3 4 5 6 7 8	0 1 2 3 4	0 1	0 1
____-____-____-41	0 1	0 1	0 1 2	0 1 2	0 1 2	0 1 2 3 4 5	0 1 2 3 4 5 6 7 8	0 1 2 3 4	0 1	0 1
____-____-____-41	0 1	0 1	0 1 2	0 1 2	0 1 2	0 1 2 3 4 5	0 1 2 3 4 5 6 7 8	0 1 2 3 4	0 1	0 1
____-____-____-41	0 1	0 1	0 1 2	0 1 2	0 1 2	0 1 2 3 4 5	0 1 2 3 4 5 6 7 8	0 1 2 3 4	0 1	0 1
____-____-____-41	0 1	0 1	0 1 2	0 1 2	0 1 2	0 1 2 3 4 5	0 1 2 3 4 5 6 7 8	0 1 2 3 4	0 1	0 1
____-____-____-41	0 1	0 1	0 1 2	0 1 2	0 1 2	0 1 2 3 4 5	0 1 2 3 4 5 6 7 8	0 1 2 3 4	0 1	0 1
____-____-____-41	0 1	0 1	0 1 2	0 1 2	0 1 2	0 1 2 3 4 5	0 1 2 3 4 5 6 7 8	0 1 2 3 4	0 1	0 1
____-____-____-41	0 1	0 1	0 1 2	0 1 2	0 1 2	0 1 2 3 4 5	0 1 2 3 4 5 6 7 8	0 1 2 3 4	0 1	0 1
____-____-____-41	0 1	0 1	0 1 2	0 1 2	0 1 2	0 1 2 3 4 5	0 1 2 3 4 5 6 7 8	0 1 2 3 4	0 1	0 1
____-____-____-41	0 1	0 1	0 1 2	0 1 2	0 1 2	0 1 2 3 4 5	0 1 2 3 4 5 6 7 8	0 1 2 3 4	0 1	0 1
____-____-____-41	0 1	0 1	0 1 2	0 1 2	0 1 2	0 1 2 3 4 5	0 1 2 3 4 5 6 7 8	0 1 2 3 4	0 1	0 1
____-____-____-41	0 1	0 1	0 1 2	0 1 2	0 1 2	0 1 2 3 4 5	0 1 2 3 4 5 6 7 8	0 1 2 3 4	0 1	0 1
____-____-____-41	0 1	0 1	0 1 2	0 1 2	0 1 2	0 1 2 3 4 5	0 1 2 3 4 5 6 7 8	0 1 2 3 4	0 1	0 1
____-____-____-41	0 1	0 1	0 1 2	0 1 2	0 1 2	0 1 2 3 4 5	0 1 2 3 4 5 6 7 8	0 1 2 3 4	0 1	0 1
____-____-____-41	0 1	0 1	0 1 2	0 1 2	0 1 2	0 1 2 3 4 5	0 1 2 3 4 5 6 7 8	0 1 2 3 4	0 1	0 1
____-____-____-41	0 1	0 1	0 1 2	0 1 2	0 1 2	0 1 2 3 4 5	0 1 2 3 4 5 6 7 8	0 1 2 3 4	0 1	0 1
____-____-____-41	0 1	0 1	0 1 2	0 1 2	0 1 2	0 1 2 3 4 5	0 1 2 3 4 5 6 7 8	0 1 2 3 4	0 1	0 1
____-____-____-41	0 1	0 1	0 1 2	0 1 2	0 1 2	0 1 2 3 4 5	0 1 2 3 4 5 6 7 8	0 1 2 3 4	0 1	0 1
____-____-____-41	0 1	0 1	0 1 2	0 1 2	0 1 2	0 1 2 3 4 5	0 1 2 3 4 5 6 7 8	0 1 2 3 4	0 1	0 1

Stanford

Rater Answer Form - Vinegar Recipe

Rater Name:______________. **Date: August___,1994**

Rater ID Number:___________ **Time: Start_______** **End_______**

Student ID No.	PART 1		PART 2			PART 3			PART 4		
	A	B	TABLE 1	A	C	Acid B	Acid C	Comp	A	B	C
___-___-____-42	0 1	0 1	0 1 2	0 1 2	0 1 2	0 1 2	0 1 2	0 1	0 1 2 3 4	0 1	0 1
___-___-____-42	0 1	0 1	0 1 2	0 1 2	0 1 2	0 1 2	0 1 2	0 1	0 1 2 3 4	0 1	0 1
___-___-____-42	0 1	0 1	0 1 2	0 1 2	0 1 2	0 1 2	0 1 2	0 1	0 1 2 3 4	0 1	0 1
___-___-____-42	0 1	0 1	0 1 2	0 1 2	0 1 2	0 1 2	0 1 2	0 1	0 1 2 3 4	0 1	0 1
___-___-____-42	0 1	0 1	0 1 2	0 1 2	0 1 2	0 1 2	0 1 2	0 1	0 1 2 3 4	0 1	0 1
___-___-____-42	0 1	0 1	0 1 2	0 1 2	0 1 2	0 1 2	0 1 2	0 1	0 1 2 3 4	0 1	0 1
___-___-____-42	0 1	0 1	0 1 2	0 1 2	0 1 2	0 1 2	0 1 2	0 1	0 1 2 3 4	0 1	0 1
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___-___-____-42	0 1	0 1	0 1 2	0 1 2	0 1 2	0 1 2	0 1 2	0 1	0 1 2 3 4	0 1	0 1
___-___-____-42	0 1	0 1	0 1 2	0 1 2	0 1 2	0 1 2	0 1 2	0 1	0 1 2 3 4	0 1	0 1
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___-___-____-42	0 1	0 1	0 1 2	0 1 2	0 1 2	0 1 2	0 1 2	0 1	0 1 2 3 4	0 1	0 1
___-___-____-42	0 1	0 1	0 1 2	0 1 2	0 1 2	0 1 2	0 1 2	0 1	0 1 2 3 4	0 1	0 1
___-___-____-42	0 1	0 1	0 1 2	0 1 2	0 1 2	0 1 2	0 1 2	0 1	0 1 2 3 4	0 1	0 1
___-___-____-42	0 1	0 1	0 1 2	0 1 2	0 1 2	0 1 2	0 1 2	0 1	0 1 2 3 4	0 1	0 1
___-___-____-42	0 1	0 1	0 1 2	0 1 2	0 1 2	0 1 2	0 1 2	0 1	0 1 2 3 4	0 1	0 1
___-___-____-42	0 1	0 1	0 1 2	0 1 2	0 1 2	0 1 2	0 1 2	0 1	0 1 2 3 4	0 1	0 1
___-___-____-42	0 1	0 1	0 1 2	0 1 2	0 1 2	0 1 2	0 1 2	0 1	0 1 2 3 4	0 1	0 1
___-___-____-42	0 1	0 1	0 1 2	0 1 2	0 1 2	0 1 2	0 1 2	0 1	0 1 2 3 4	0 1	0 1

Rater Answer Form - Vinegar Text

Rater Name:_______________ **Date: August___,1994**

Rater ID Number:___________ **Time: Start_______ End_____**

Student ID No.	PART 1 A	PART 1 B	PART 2 A	PART 2 B	PART 2 C	PART 3 A	PART 3 B	PART 3 C	PART 4 A	PART 4 B	PART 4 C
___-___-____-43	0 1	0 1	0 1 2	0 1	0 1 2	0 1	0 1	0 1 2	0 1 2 3 4	0 1	0 1
___-___-____-43	0 1	0 1	0 1 2	0 1	0 1 2	0 1	0 1	0 1 2	0 1 2 3 4	0 1	0 1
___-___-____-43	0 1	0 1	0 1 2	0 1	0 1 2	0 1	0 1	0 1 2	0 1 2 3 4	0 1	0 1
___-___-____-43	0 1	0 1	0 1 2	0 1	0 1 2	0 1	0 1	0 1 2	0 1 2 3 4	0 1	0 1
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___-___-____-43	0 1	0 1	0 1 2	0 1	0 1 2	0 1	0 1	0 1 2	0 1 2 3 4	0 1	0 1
___-___-____-43	0 1	0 1	0 1 2	0 1	0 1 2	0 1	0 1	0 1 2	0 1 2 3 4	0 1	0 1
___-___-____-43	0 1	0 1	0 1 2	0 1	0 1 2	0 1	0 1	0 1 2	0 1 2 3 4	0 1	0 1
___-___-____-43	0 1	0 1	0 1 2	0 1	0 1 2	0 1	0 1	0 1 2	0 1 2 3 4	0 1	0 1
___-___-____-43	0 1	0 1	0 1 2	0 1	0 1 2	0 1	0 1	0 1 2	0 1 2 3 4	0 1	0 1
___-___-____-43	0 1	0 1	0 1 2	0 1	0 1 2	0 1	0 1	0 1 2	0 1 2 3 4	0 1	0 1
___-___-____-43	0 1	0 1	0 1 2	0 1	0 1 2	0 1	0 1	0 1 2	0 1 2 3 4	0 1	0 1
___-___-____-43	0 1	0 1	0 1 2	0 1	0 1 2	0 1	0 1	0 1 2	0 1 2 3 4	0 1	0 1
___-___-____-43	0 1	0 1	0 1 2	0 1	0 1 2	0 1	0 1	0 1 2	0 1 2 3 4	0 1	0 1
___-___-____-43	0 1	0 1	0 1 2	0 1	0 1 2	0 1	0 1	0 1 2	0 1 2 3 4	0 1	0 1
___-___-____-43	0 1	0 1	0 1 2	0 1	0 1 2	0 1	0 1	0 1 2	0 1 2 3 4	0 1	0 1
___-___-____-43	0 1	0 1	0 1 2	0 1	0 1 2	0 1	0 1	0 1 2	0 1 2 3 4	0 1	0 1
___-___-____-43	0 1	0 1	0 1 2	0 1	0 1 2	0 1	0 1	0 1 2	0 1 2 3 4	0 1	0 1

Rater Answer Form - Vinegar Parts 4D, 4E, 4F: All Versions

Rater Name:______________ Date: August____,1994

Rater ID Number:__________ Time: Start______ End______

Student ID No.	PART 4 4d-1	4d-2 (0-5 pt)	4e	4f
______-______-______-______	0 1	0 1 2 3 4 5	0 1	0 1 2 3
______-______-______-______	0 1	0 1 2 3 4 5	0 1	0 1 2 3
______-______-______-______	0 1	0 1 2 3 4 5	0 1	0 1 2 3
______-______-______-______	0 1	0 1 2 3 4 5	0 1	0 1 2 3
______-______-______-______	0 1	0 1 2 3 4 5	0 1	0 1 2 3
______-______-______-______	0 1	0 1 2 3 4 5	0 1	0 1 2 3
______-______-______-______	0 1	0 1 2 3 4 5	0 1	0 1 2 3
______-______-______-______	0 1	0 1 2 3 4 5	0 1	0 1 2 3
______-______-______-______	0 1	0 1 2 3 4 5	0 1	0 1 2 3
______-______-______-______	0 1	0 1 2 3 4 5	0 1	0 1 2 3
______-______-______-______	0 1	0 1 2 3 4 5	0 1	0 1 2 3
______-______-______-______	0 1	0 1 2 3 4 5	0 1	0 1 2 3
______-______-______-______	0 1	0 1 2 3 4 5	0 1	0 1 2 3
______-______-______-______	0 1	0 1 2 3 4 5	0 1	0 1 2 3
______-______-______-______	0 1	0 1 2 3 4 5	0 1	0 1 2 3
______-______-______-______	0 1	0 1 2 3 4 5	0 1	0 1 2 3
______-______-______-______	0 1	0 1 2 3 4 5	0 1	0 1 2 3
______-______-______-______	0 1	0 1 2 3 4 5	0 1	0 1 2 3
______-______-______-______	0 1	0 1 2 3 4 5	0 1	0 1 2 3
______-______-______-______	0 1	0 1 2 3 4 5	0 1	0 1 2 3
______-______-______-______	0 1	0 1 2 3 4 5	0 1	0 1 2 3
______-______-______-______	0 1	0 1 2 3 4 5	0 1	0 1 2 3
______-______-______-______	0 1	0 1 2 3 4 5	0 1	0 1 2 3
______-______-______-______	0 1	0 1 2 3 4 5	0 1	0 1 2 3
______-______-______-______	0 1	0 1 2 3 4 5	0 1	0 1 2 3

9. Acids and Bases—Alien

The Acids and Bases shell tasks were designed by the University of California, Santa Barbara, and a team from Stanford University and the Far West Laboratory. The tasks were administered to eighth-grade students in 1994.

The shell used for designing the alien task is identical to that for the vinegar task (see Section 8). The shell describes three versions of the task at different levels of inquiry.

- "Discovery," in which the student must design and perform the experiment.
- "Recipe," in which the student is guided through the experiment.
- "Text," in which the student reads about an experiment conducted by another but does not use any apparatus.

Each research group worked independently to develop a task. The alien task developed by the UCSB team requires that students determine which of two solutions is the more acidic by adding each to a given base. Students have to apply the process to a problem involving an alien creature.

A list of the solution concentrations used in the tasks follows the task forms.

The components of the alien task will be found on the following pages:

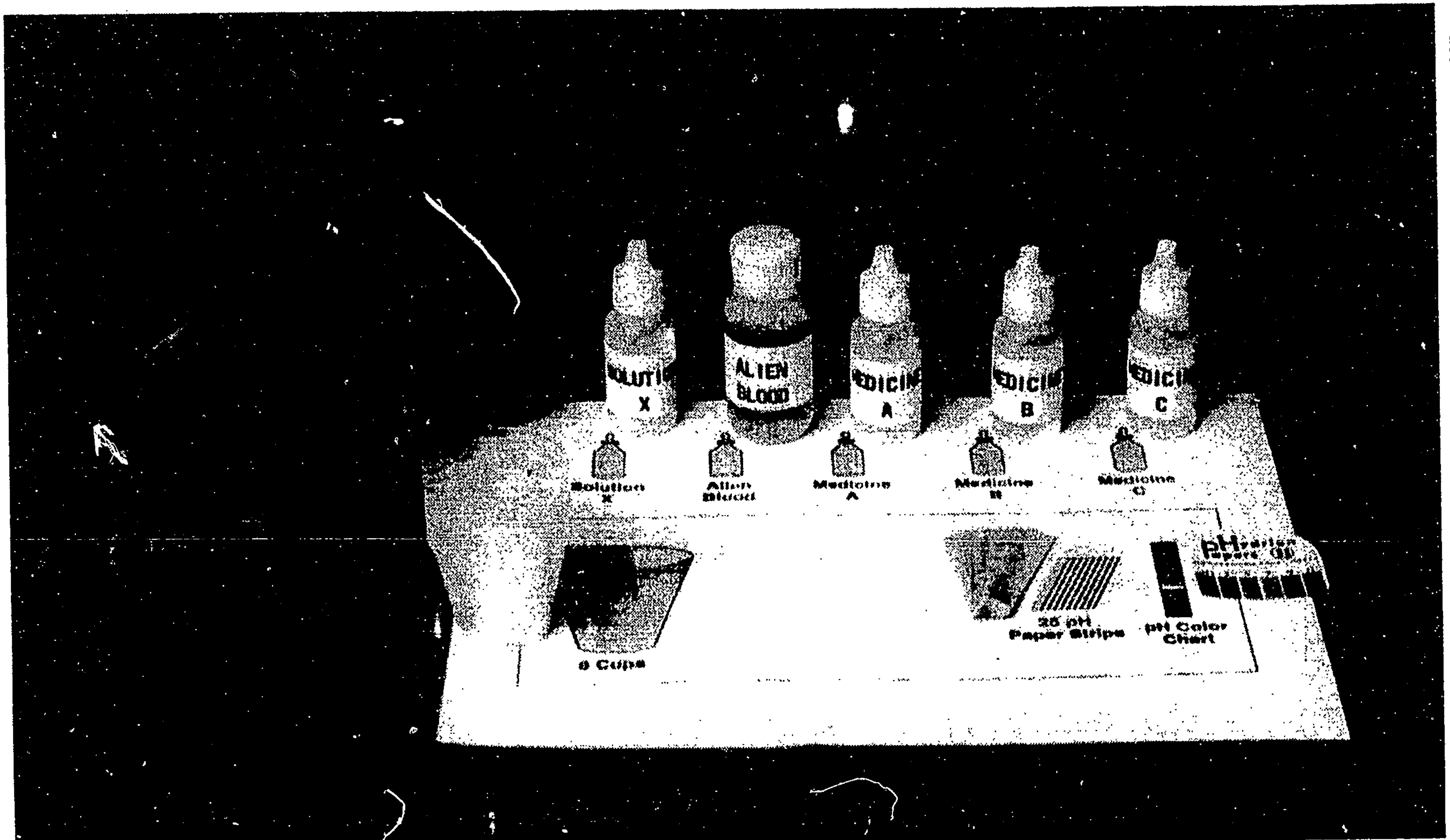


Figure 11—Equipment for Acids and Bases—Alien

Task page 1

ACIDS AND BASES - FORM D

Name: ______________________________ Teacher: ________________________
First Last

Please Circle: Male Female

Date of Birth: ____/____/____
month day year

INSTRUCTIONS

In this activity you will be working by yourself. You can write your answers directly on these pages. If you have a question, please raise your hand and we will come to help you.

Please take the materials out of the bag in front of you. Put the materials on your placemat. Raise your hand if you are missing any of these materials:

MATERIALS

1 bag pH indicator paper strips
1 pH Color Chart
8 plastic measuring cups
1 dropper bottle **Solution X**
1 dropper bottle **Alien Blood**
1 dropper bottle **Medicine A**
1 dropper bottle **Medicine B**
1 dropper bottle **Medicine C**

GO TO NEXT PAGE

Task page 2

All solutions are acids, bases, or neutral. You can use pH paper and a pH Color Chart to test whether a solution is an acid, a base or neutral.

Part 1: READING THE pH SCALE

To practice using the pH paper:

- Squeeze 6 drops of Solution X into one of the measuring cups. Gently swirl the cup.

- Take one strip of pH paper out of the bag, and dip it into Solution X.

- Remove the strip from the cup and quickly observe the color of the pH paper. **Be sure to look at the color right away, because it will change quickly. The first color shows the correct pH.**

1a. What is the **color** of the pH paper right after you dipped it into Solution X?

____

1b. What **number** on the pH Color Chart goes with this color? __________

1c. Look at the chart below. Is Solution X an acid, a base, or neutral? __________

pH levels

1	3	5	7	9	11
Pink	Rust/ Brown	Golden- Orange	Greenish- Yellow	Dark Green	Blue
ACIDS			NEUTRAL	BASES	

GO TO NEXT PAGE

Task page 3

Part 2: THE PROBLEM

You are an expert in blood chemistry. The blood of an alien creature is brought to your laboratory for analysis. The alien has a severe headache and a high temperature. The doctors say the alien has a sickness called acidosis-basicosis. This condition is caused by the blood being either too acidic (low pH) or too basic (high pH).

The normal pH for alien blood is 7.0. The alien will die if its blood stays away from 7.0 for more than a few hours.

To find out what is wrong with the alien, test the pH of its blood to see if it is too acidic or too basic.

- **Squeeze 6 drops of the alien's blood into a new measuring cup.**
- **Test the pH of the alien's blood using a new strip of pH paper and the Color Chart.**

2a. What was the **color** of the pH paper right after you took it out of the alien's blood? __________

2b. What **number** on the pH Color Chart goes with this color? ______________

2c. The alien is suffering from acidosis/basicosis because its blood is (circle the right choice):

A) Too acidic

B) Too basic

C) Too neutral

Part 3: FINDING THE BEST MEDICINE

The alien's spaceship has a first aid kit with three medicines. One or more of these medicines can cure acidosis-basicosis when it is added to the alien's blood.

Your job is to figure out which medicine (A, B, or C) will save the alien's life by bringing the pH of its blood back to normal.

You should use the materials in front of you to conduct whatever experiments you think are needed to find out which medicine is best. Remember, **always swirl a solution before you test it, and always use a new piece of pH paper for each test.**

GO TO NEXT PAGE

Task page 4

3a. Record the results of your experiment in the table below as you work.

SOLUTION TESTED	RESULTS

GO TO NEXT PAGE

Task page 5

3b. Write down and number the steps you followed as you conducted your experiment. Be specific, so another student in your class could conduct the experiment exactly as you did. For example, if you mixed solutions together, tell how much of each solution you used.

GO TO NEXT PAGE

Task page 6

Part 4: DRAWING CONCLUSIONS

Use the results of your experiment to answer the following questions:

4a. Which is the best medicine (A, B or C) for the alien? __________

4b. Why is this medicine better than the other medicines? (You may use a table, graph, or picture to help explain your answer).

____

____

____

____

____

____

4c. How can a basic solution be turned into a neutral solution?

____

____

4d. How can an acidic solution be turned into a neutral solution?

____

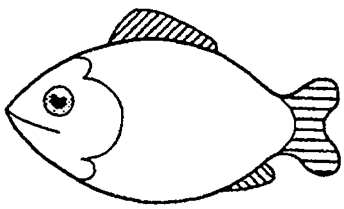
____

GO TO NEXT PAGE

Task page 7

Part 5: USING WHAT YOU LEARNED

The people of Spring City were concerned because the fish in their pond were dying. They hired an environmental scientist who measured the pond's pH and found that it was too acidic. Pond fish need neutral water to survive. The people followed the specialist's advice and added Pro-Base, (a strong base) to the pond. After two days, the fish stopped dying. The people kept adding Pro-Base to the water and after three more days, the fish started dying again. In fact, the more Pro-Base they added, the more fish died.



5a. Why did ProBase work at first, but not continue to work?

____

5b. What should the people in Spring City do now to save the fish in their pond? (Circle the best choice).

A) Add no more chemicals
B) Add an acidic substance
C) Add a neutral substance
D) Add more Pro-Base

5c. Why did you choose this answer?

GO TO NEXT PAGE

Task page 1

ACIDS AND BASES - FORM R

Name: ______________________________ Teacher: ______________________
First Last

Please Circle: Male Female

Date of Birth: _____/_____/_____
month day year

INSTRUCTIONS

In this activity you will be working by yourself. You can write your answers directly on these pages. If you have a question, please raise your hand and we will come to help you.

Please take the materials out of the bag in front of you. Put the materials on your placemat. Raise your hand if you are missing any of these materials:

MATERIALS

1 bag pH indicator paper strips	1 dropper bottle **Alien Blood**
1 pH Color Chart	1 dropper bottle **Medicine A**
8 plastic measuring cups	1 dropper bottle **Medicine B**
1 dropper bottle **Solution X**	1 dropper bottle **Medicine C**

GO TO NEXT PAGE

Task page 2

All solutions are acids, bases, or neutral. You can use pH paper and a pH Color Chart to test whether a solution is an acid, a base or neutral.

Part 1: READING THE pH SCALE

To practice using the pH paper:

- Squeeze 6 drops of Solution X into one of the measuring cups. Gently swirl the cup.
- Take one strip of pH paper out of the bag, and dip it into Solution X.
- Remove the strip from the cup and <u>quickly observe</u> the color of the pH paper. Be **sure to look at the color right away, because it will change quickly. The first color shows the correct pH.**

1a. What is the **color** of the pH paper right after you dipped it into Solution X?

____

1b. What **number** on the pH Color Chart goes with this color? ____________

1c. Look at the chart below. Is Solution X an acid, a base, or neutral? _______

pH levels

1	3	5	7	9	11
Pink	Rust/ Brown	Golden-Orange	Greenish-Yellow	Dark Green	Blue
ACIDS			NEUTRAL	BASES	

GO TO NEXT PAGE

Task page 3

Part 2: THE PROBLEM

You are an expert in blood chemistry. The blood of an alien creature is brought to your laboratory for analysis. The alien has a severe headache and a high temperature. The doctors say the alien has a sickness called acidosis-basicosis. This condition is caused by the blood being either too acidic (low pH) or too basic (high pH).

The normal pH for alien blood is 7.0. The alien will die if its blood stays away from 7.0 for more than a few hours.

To find out what is wrong with the alien, test the pH of its blood to see if it is too acidic or too basic.

- **Squeeze 6 drops of the alien's blood into a new measuring cup.**
- **Test the pH of the alien's blood using a new strip of pH paper and the Color Chart.**

2a. What was the **color** of the pH paper right after you took it out of the alien's blood? __________

2b. What **number** on the pH Color Chart goes with this color? ____________

2c. The alien is suffering from acidosis/basicosis because its blood is (circle the right choice):

A) Too acidic

B) Too basic

C) Too neutral

Part 3 - FINDING THE BEST MEDICINE

The alien's spaceship has a first aid kit with three medicines. One or more of these medicines can cure acidosis-basicosis when it is added to the alien's blood.

Your job is to use the material in front of you to figure out which medicine (A, B, or C) will save the alien's life by bringing the pH of its blood back to normal.

GO TO THE NEXT PAGE

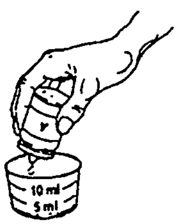
Task page 4

You will do this in two stages. In Stage I, you will test the pH of each medicine. In Stage II, you will test what happens when you combine the alien's blood with each medicine.

Follow the steps below and record the results of your experiment in the table on the opposite page as you work.

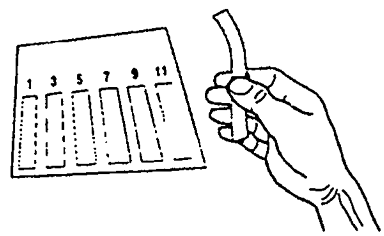
Stage I - Testing the Medicines

1. To test Medicine A:



Squeeze 3 drops of Medicine A into a clean cup.

Dip a new piece of pH paper into the solution.



Quickly match the color of the pH paper with the Color Chart.

2. Record your results in Table 1, making sure that you describe both the color of the pH paper and its pH number.
3. Repeat Steps 1 and 2 for Medicine B with a **new cup** and **new pH strip.**
4. Repeat Steps 1 and 2 for Medicine C with a **new cup** and **new pH strip.**

Stage II - Testing Mixtures

5. Fill a **new cup** up to the 5ml level with alien blood.
6. Add 3 drops of Medicine A to the cup, gently swirl the cup, dip a **new piece of pH paper** into the solution, and quickly match the color on the pH paper with the Color Chart.
7. Record the color of the pH paper and the pH number in Table 1.
8. Add 3 more drops of Medicine A to the cup, gently swirl the cup, dip a **new piece of pH paper** into the solution, and quickly match the color on the pH paper with the Color Chart.
9. Record the color of the pH paper and the pH number in Table 1.
10. Repeat steps 5-9 using Medicine B.
11. Repeat steps 5-9 using Medicine C.

GO TO NEXT PAGE

Task page 5

Table 1

Solution Tested	Color	pH Number
3 drops Medicine A		
3 drops Medicine B		
3 drops Medicine C		
5ml blood + 3 drops Medicine A		
5ml blood + 6 drops Medicine A		
5ml blood + 3 drops Medicine B		
5ml blood + 6 drops Medicine B		
5ml blood + 3 drops Medicine C		
5ml blood + 6 drops Medicine C		

GO TO NEXT PAGE

Task page 6

Part 4: DRAWING CONCLUSIONS

Use the results of your experiment to answer the following questions:

4a. Which is the best medicine (A, B or C) for the alien? ___________

4b. Why is this medicine better than the other medicines? (You may use a table, graph, or picture to help explain your answer).

____

____

____

____

____

____

4c. How can a basic solution be turned into a neutral solution?

____

____

4d. How can an acidic solution be turned into a neutral solution?

____

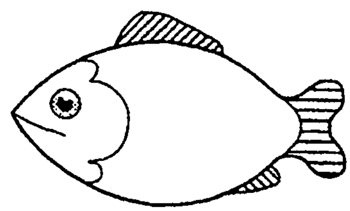
____

GO TO NEXT PAGE

Task page 7

Part 5: USING WHAT YOU LEARNED

The people of Spring City were concerned because the fish in their pond were dying. They hired an environmental scientist who measured the pond's pH and found that it was too acidic. Pond fish need neutral water to survive. The people followed the specialist's advice and added Pro-Base, (a strong base) to the pond. After two days, the fish stopped dying. The people kept adding Pro-Base to the water and after three more days, the fish started dying again. In fact, the more Pro-Base they added, the more fish died.



5a. Why did ProBase work at first, but not continue to work?

____

____

____

____

____

5b. What should the people in Spring City do now to save the fish in their pond? (Circle the best choice).

A) Add no more chemicals

B) Add an acidic substance

C) Add a neutral substance

D) Add more Pro-Base

5c. Why did you choose this answer?

____

____

____

GO TO NEXT PAGE

Task page 1

ACIDS AND BASES - FORM T

Name: ______________________________ Teacher: ______________________
First Last

Please Circle: Male Female

Date of Birth: ____/____/____
month day year

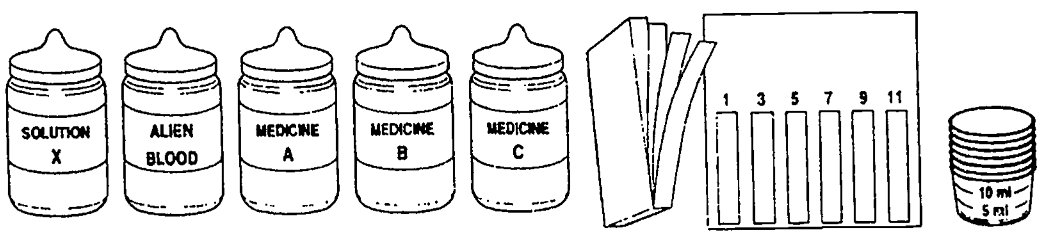
INSTRUCTIONS

In this activity you will be working by yourself. You can write your answers directly on these pages. If you have a question, please raise your hand and we will come to help you.

Part 1: READING THE pH SCALE

All solutions are acids, bases or neutrals. Chemists use pH paper and a pH Color Chart to test whether a solution is an acid, base or neutral.

Anna is a chemist. Here are the materials she used to do some experiments.



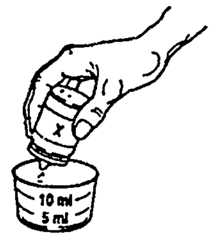
pH Strips pH Chart Measuring Cups

GO TO NEXT PAGE

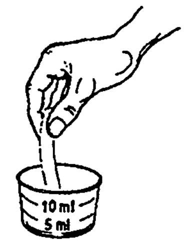
Task page 2

In her first experiment, Anna tested Solution X:

- She put 6 drops of Solution X into one of the measuring cups.



- She dipped a strip of pH paper into the cup.



- She removed the pH strip from the cup and observed that it had turned orange.
- She looked at the pH Color Chart below to find the pH number that goes with orange.

pH levels

1	3	5	7	9	11
Red	Pink	Orange	Yellow	Green	Blue

ACIDS (1–5)　NEUTRAL (7)　BASES (9–11)

1a. What is the pH **number** of Solution X? __________

1b. Is Solution X an acid, a base, or neutral? __________

GO TO NEXT PAGE

Task page 3

Part 2: THE PROBLEM

Anna is an expert in blood chemistry. The blood of an alien creature is brought to her laboratory for analysis. The alien has a severe headache and a high temperature. The doctors say the alien has a sickness called acidosis-basicosis. This condition is caused by the blood being either too acidic (low pH) or too basic (high pH).

The normal pH for alien blood is 7.0. The alien will die if its blood stays away from 7.0 for more than a few hours.

To find out what is wrong with the alien, Anna tests the pH of the alien's blood to see if it is too acidic or too basic.

- She puts 6 drops of the alien's blood into a measuring cup.

- She dips a strip of pH paper into the cup. The pH paper turns Green.

2a. What is the pH **number** for Green on the pH Color Chart? _______________

2b. This result means the alien is suffering from acidosis/basicosis because its blood is (circle the right choice):

A) Too acidic

B) Too basic

C) Too neutral

Part 3: FINDING THE BEST MEDICINE

The alien's spaceship has a first aid kit with three medicines. One or more of these medicines can cure acidosis-basicosis when it is added to the alien's blood.

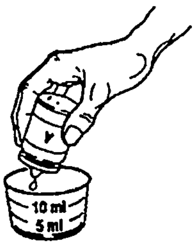
Anna's job is to figure out which medicine (A, B, or C) will save the alien's life by bringing the pH of its blood back to normal.

She does this by conducting an experiment in two stages. First, she tests the pH of each medicine. She then tests what happens when she combines the alien's blood with each medicine.

GO TO NEXT PAGE

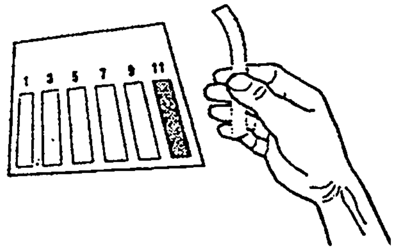
Task page 4

1. To test Medicine A:



Anna puts 3 drops of Medicine A in a clean cup.

She dips a new piece of pH paper into the solution.



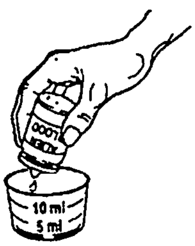
She compares the color of the pH paper to the Color Chart.

2. Because the strip turned Blue, Anna writes Blue and the pH number 11 in Table 1.

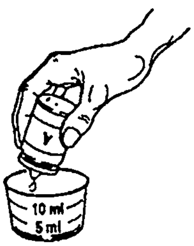
3. She tested Medicine B the same way and found that it turned the pH strip Yellow. What pH **number** goes with Medicine B? __________ Put this number in the right place on Table 1.

4. She tested Medicine C the same way and found that it turned the pH strip Red. What pH **number** goes with Medicine C? __________ Put this number in the right place on Table 1.

5. Anna now begins to test the pH of the alien's blood when she mixes it with a medicine.

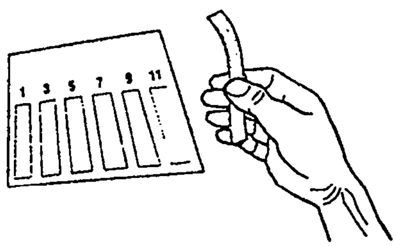


She puts 5ml of alien blood in a new cup.



She adds 3 drops of Medicine A.

She dips a new piece of pH paper into the solution.



She compares the color of the pH paper to the Color Chart.

6. Because the strip turns Green, Anna writes Green in Table 1. What pH number goes with Green? ______________ Put this number in Table 1.

GO TO NEXT PAGE

Task page 5

7. Anna adds 3 more drops of Medicine A to the cup and dips a new piece of pH paper into it. The pH paper turns Green again.

8. Anna repeats steps 5-7 with Medicine B.

9. Anna repeats steps 5-7 with Medicine C.

10. Table 1 shows the color of the pH paper for each of Anna's tests. Your job is to finish the table by recording the pH number for each color.

TABLE 1

Solution Tested	Color	pH Number
3 drops Medicine A	Blue	11
3 drops Medicine B	Yellow	
3 drops Medicine C	Red	
5ml blood + 3 drops Medicine A	Blue	
5ml blood + 6 drops Medicine A	Blue	
5ml blood + 3 drops Medicine B	Green	
5ml blood + 6 drops Medicine B	Green	
5ml blood + 3 drops Medicine C	Yellow	
5ml blood + 6 drops Medicine C	Orange	

GO TO NEXT PAGE

Task page 6

Part 4: DRAWING CONCLUSIONS

Use the results of Table 1 to answer the following questions:

4a. Which is the best medicine (A, B or C) for the alien? ___________

4b. Why is this medicine better than the other medicines? (You may use a table, graph, or picture to help explain your answer).

4c. How can a basic solution be turned into a neutral solution?

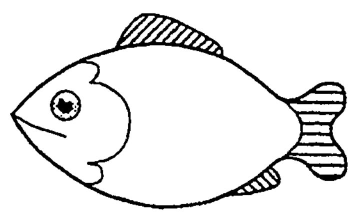
4d. How can an acidic solution be turned into a neutral solution?

GO TO NEXT PAGE

Task page 7

Part 5: USING WHAT YOU LEARNED

The people of Spring City were concerned because the fish in their pond were dying. They hired an environmental scientist who measured the pond's pH and found that it was too acidic. Pond fish need neutral water to survive. The people followed the specialist's advice and added Pro-Base, (a strong base) to the pond. After two days, the fish stopped dying. The people kept adding Pro-Base to the water and after three more days, the fish started dying again. In fact, the more Pro-Base they added, the more fish died.



5a. Why did ProBase work at first, but not continue to work?

5b. What should the people in Spring City do now to save the fish in their pond? (Circle the best choice).

A) Add no more chemicals
B) Add an acidic substance
C) Add a neutral substance
D) Add more Pro-Base

5c. Why did you choose this answer?

SOLUTION CONCENTRATIONS FOR ACIDS AND BASES - ALIEN

Solution X	0.1 ml 5% vinegar and 9.9 ml deionized water
Alien blood	0.03 ml 5% ammonia and 9.97 ml deionized water plus blue dye
Medicine A	3 ml 5% ammonia and 7 ml deionized water
Medicine B	Distilled water
Medicine C	5 ml 5% vinegar and 6 ml deionized water

Scoring Guide - Acids and Bases (Alien Discovery Version)

PART 1 (Page 2)

1a	1pt	Orange, golden-orange
1b	1 pt	5
1c	1 pt	Acid

PART 2 (Page 3)

2a	1 pt	Green, Dark green
	Note: Blue, Dark blue, Blue-green are not acceptable.	
2b	1 pt	9
2c	1 pt	B (too basic)

PART 3 (Pages 4 and 5. Score questions 3a and 3b together.)

A. Medicines tested (**Meds**)

3 pts 1 pt. for each medicine tested, either separately or against blood. (There must be some indication of testing; e.g., give no points for the letter A alone with nothing in the results column.) It is OK to include Solution X in these tests if it is included in all three tests.

1 pt Medicines tested against blood (Bonus point).

Note: It's OK if the student made other tests besides the ones for which he/she is awarded points.

B. Drops of medicine and blood (**Drops**)

1 pt Recorded number of drops of medicine used. Needs to record for at least two medicines or for the same medicine two different times. It is OK to say "repeat the same steps for Medicines B and C."

1 pt Constant amount of blood used in comparing the medicines. Needs to use same amount in testing all 3 medicines independently before experimenting with different amounts. (Award point if student dips all strips into blood first and then drops medicines on blood-soaked strips if they say "dip strips to the same depth" or other instruction to indicate constant saturation.) Award point if amount is given for one test, and then student says something like, "repeat the same steps for medicines B and C."

1 pt Constant number of drops of medicine added to the blood. Needs to use same amount in testing all 3 medicines independently before experimenting with different amounts. No points if medicines are not

tested against blood. Award point if amount is given for one test, and then student says something like, "repeat the same steps for medicines B and C."

Note: If student tested only Medicine C plus blood and reached the right (neutral) solution and recorded the number of drops of both substances accurately, award 2 pts total for Drops.

C. Accuracy of Results (**Result**)

3 pts 1 pt for each correct pH or color reported. Maximum of 3 points.

Medicines only:	A	10-11	Base	Blue, Purple
	B	6-8	Neutral	Greenish Yellow, Yellow
	C	1-3	Acid	Pink, Rust Brown, Red
With blood:	A	10-11	Base	Blue, Purple
	B	9	Base	Green, Dark Green
	C	1-8	Neutral, Acid	Light Green, Yellow, Golden-Orange, Pink, Red, Rust Brown

Note: If student lists two sets of results (e.g., one for medicines alone and one for medicines plus blood), award points for whichever set has higher score. If student lists three sets of results, award points for medicines for which at least two of the three results are correct.

Scoring Guide - Acids and Bases (Alien Discovery Version, Continued)

D. Procedures (**Proc**)

1 pt Uses **clean** cup, if mentioned at least once, or uses multiple cups.

Note: "Use **separate** cups" or "put in **each** cup" or "**per** cup" also acceptable.

1 pt Use **new** pH strip, if mentioned at least once.

1 pt **Swirl** solution in cup, if mentioned at least once. (Also award point for "stir," "mix," and other synonyms.)

E. Conclusion (**Con**)

1 pt Tells when to stop, explains goal, or states a conclusion. E.g. "Stop when you get a yellow color", "Medicine C is better -- we have found a cure." The statement does not have to be correct, just a goal or a conclusion."

PART 4: (Page 6)

4a 1 pt Medicine C

Note: 4a is a gateway point for 4b. Award no points for 4b if 4a is incorrect. *Also, since students using small amounts of alien blood may have found that C was too strong and thus attempted to dilute its strength, a combination of A and C, or B and C is acceptable. However, to award the point for a combination of medicines, the answer must agree with the results of Part 3a & b.* [We did not use the rule in italics in scoring 8/94, but it is a good rule and should be a part of the final rubric.]

4b 1 pt C (or the combination) brings the blood back to normal or neutral or pH of 7

1 pt Mentions one or more of the following:

1) C (or C+A; C+B) is acidic and the blood is too basic.
2) C (or C+A; C+B) lowers the pH of the blood.
3) Medicine A made the blood more basic and B had no effect.

Note: Award no points for 4b if the student states that medicine C (or the combination) itself is closer to neutral; the correct answer is that C can **neutralize** the blood.

4c 1 pt By adding any one of the following or any combination of them (a combination can

include Medicine B as well): "Adding an acid and a base" is wrong.

1) an acid
2) Solution X
3) Medicine C

4d 1 pt By adding either of the following or a combination of them (a combination can include Medicine B as well):

1. a base
2. Medicine A

Scoring Guide - Acids and Bases
(Alien Recipe Version)

PART 1: (Page 2)
1a 1pt Orange, golden-orange
1b 1 pt 5
1c 1 pt Acid

PART 2: (Page 3)
2a 1 pt Green, Dark green, Greenish-blue.
Note: Blue, Dark blue, Blue-green are not acceptable.
2b 1 pt 9
2c 1 pt B (too basic)

PART 3: (Page 5)
Table 1
9 pts
Score 1 point for each correct pH number. If the number is wrong, mark the answer incorrect, even if the student has listed the correct color. However, if the number is missing, award points for correct color.

Row 1	10-11	Blue, Purple
Row 2	6-8	Greenish Yellow, Yellow
Row 3	1-3	Pink, Rust Brown, Red
Row 4	9-11	Dark Green, Green, Blue
Row 5	11	Blue, Purple
Row 6	9	Green
Row 7	9	Green
Row 8	6-8	Yellow, Greenish Yellow, Light Green
Row 9	4-6	Yellow-Orange, Orange, Golden Orange

(Row 9 must have a lower pH number or more acidic color than row 8.)

PART 4: (Page 6)
4a 1 pt Medicine C
Note: 4a is a gateway point for 4b. Award no points for 4b if 4a is incorrect.

4b 1 pt C brings the blood back to normal or neutral or pH of 7 or to yellow or “evens out,” “balances” or “stabilizes” the blood.
1 pt Mentions one or more of the following:
1) C is an acid and the blood is too basic.
2) C lowers the pH of the blood (to yellow or neutral).
3) Medicine A made the blood more basic and B had no effect.

Note: “It” rule: If the students uses the pronoun “it” the reference must clearly be to the solution of medicine and blood not just to the medicine. If this is not clear, award no points.

Scoring Guide - Acids and Bases
(Alien Recipe Version, Continued)

Note: Award no points for 4b if the student states that medicine C itself is closer to neutral; the correct answer is that medicine C can **neutralize** the blood.

4c 1 pt By adding any one of the following or any combination of them (a combination can include Medicine B as well):
1) an acid or a solution with a low pH.
2) Solution X
3) Medicine C

4d 1 pt By adding either of the following or a combination of them (a combination can include Medicine B as well):
1) a base or a solution with a high pH.
2) Medicine A

Scoring Guide - Acids and Bases (Alien Text Version)

PART 1 (Page 2)

1a	1 pt	5
1b	1 pt	Acid

PART 2 (Page 3)

2a	1pt	9
2b	1 pt	B (too basic)

PART 3 (Page 5)

Table
1 8 pts

Score 1 point for each correct pH number. If rows 2-4 have no answer, award points for correct answers in the corresponding blanks on p. 4:

Question 3 corresponds to row 2, question 4 to row 3, and question 6 to row 4. If answers are given in both places, score the answers in the table, even if they are wrong and the answers on page 4 are correct.

Row 2	7
Row 3	1
Row 4	11
Row 5	11
Row 6	9
Row 7	9
Row 8	7
Row 9	5

PART 4: (Page 6)

4a 1 pt Medicine C
Note: 4a is a gateway point for 4b. Award no points for 4b if 4a is incorrect.

4b 1 pt C brings the blood back to normal or neutral or pH of 7 or to yellow or "evens out," "balances" or "stabilizes" the blood.

1 pt Mentions one or more of the following:
1) C is an acid and the blood is too basic.
2) C lowers the pH of the blood (to yellow or neutral).
3) Medicine A made the blood more basic and B had no effect.

Note: Award no points for 4b if the student states that medicine C itself is closer to neutral; the correct answer is that medicine C can **neutralize** the blood.

4c 1 pt By adding any one of the following or any combination of them:

1) an acid or a solution with a low pH.
2) Solution X
3) Medicine C

4d 1 pt By adding any one of the following or any combination of them:
1) a base or a solution with a high pH.
2) Medicine A

Scoring Guide - Acids and Bases
(Alien Part 5 -- All Versions)

PART 5 (Page 7)

5a 1 pt Fish stopped dying because ProBase made the pond less acidic, returned the pH to neutral, or balanced the water.

1 pt Fish began dying again because additional ProBase made the pond water too basic, or the pH went past neutral to make the pond basic.

Note: Answers which make no reference to "base" or "neutral" or pH -- e.g., "They gave it too much," or "They need to give it less" or "it was too strong" or "they gave it the right amount" -- are not acceptable.

5b 1 pt B (Add an acidic substance)

5c 1 pt The acid is needed to bring the water from a base back to neutral pH. E.g. "It brings it back to neutral." "To reverse the process" or "balance the water" is also an acceptable answer.
1 pt But stop adding acid when the water has become neutral. The response must provide enough information to tell how to proceed correctly, e.g., what amount is needed to get to neutral, or what actions would disrupt neutrality.

Rater Answer Form - Acids and Bases (Alien Discovery Version)

Rater Name: ________________ Date: August ___, 1994

Rater ID Number: ______________ Time: Start _____ End: _____

Student ID	Part 1 A	Part 1 B	Part 1 C	Part 2 A	Part 2 B	Part 2 C	Part 3 Meds	Part 3 Drops	Part 3 Result	Part 3 Proc	Part 3 Con	Part 4 A	Part 4 B	Part 4 C	Part 4 D
____-____-____-31	0 1	0 1	0 1	0 1	0 1	0 1	0 1 2 3 4	0 1 2 3	0 1 2 3	0 1 2 3	0 1	0 1	0 1 2	0 1	0 1
____-____-____-31	0 1	0 1	0 1	0 1	0 1	0 1	0 1 2 3 4	0 1 2 3	0 1 2 3	0 1 2 3	0 1	0 1	0 1 2	0 1	0 1
____-____-____-31	0 1	0 1	0 1	0 1	0 1	0 1	0 1 2 3 4	0 1 2 3	0 1 2 3	0 1 2 3	0 1	0 1	0 1 2	0 1	0 1
____-____-____-31	0 1	0 1	0 1	0 1	0 1	0 1	0 1 2 3 4	0 1 2 3	0 1 2 3	0 1 2 3	0 1	0 1	0 1 2	0 1	0 1
____-____-____-31	0 1	0 1	0 1	0 1	0 1	0 1	0 1 2 3 4	0 1 2 3	0 1 2 3	0 1 2 3	0 1	0 1	0 1 2	0 1	0 1
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____-____-____-31	0 1	0 1	0 1	0 1	0 1	0 1	0 1 2 3 4	0 1 2 3	0 1 2 3	0 1 2 3	0 1	0 1	0 1 2	0 1	0 1
____-____-____-31	0 1	0 1	0 1	0 1	0 1	0 1	0 1 2 3 4	0 1 2 3	0 1 2 3	0 1 2 3	0 1	0 1	0 1 2	0 1	0 1
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____-____-____-31	0 1	0 1	0 1	0 1	0 1	0 1	0 1 2 3 4	0 1 2 3	0 1 2 3	0 1 2 3	0 1	0 1	0 1 2	0 1	0 1
____-____-____-31	0 1	0 1	0 1	0 1	0 1	0 1	0 1 2 3 4	0 1 2 3	0 1 2 3	0 1 2 3	0 1	0 1	0 1 2	0 1	0 1
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____-____-____-31	0 1	0 1	0 1	0 1	0 1	0 1	0 1 2 3 4	0 1 2 3	0 1 2 3	0 1 2 3	0 1	0 1	0 1 2	0 1	0 1
____-____-____-31	0 1	0 1	0 1	0 1	0 1	0 1	0 1 2 3 4	0 1 2 3	0 1 2 3	0 1 2 3	0 1	0 1	0 1 2	0 1	0 1
____-____-____-31	0 1	0 1	0 1	0 1	0 1	0 1	0 1 2 3 4	0 1 2 3	0 1 2 3	0 1 2 3	0 1	0 1	0 1 2	0 1	0 1
____-____-____-31	0 1	0 1	0 1	0 1	0 1	0 1	0 1 2 3 4	0 1 2 3	0 1 2 3	0 1 2 3	0 1	0 1	0 1 2	0 1	0 1
____-____-____-31	0 1	0 1	0 1	0 1	0 1	0 1	0 1 2 3 4	0 1 2 3	0 1 2 3	0 1 2 3	0 1	0 1	0 1 2	0 1	0 1
____-____-____-31	0 1	0 1	0 1	0 1	0 1	0 1	0 1 2 3 4	0 1 2 3	0 1 2 3	0 1 2 3	0 1	0 1	0 1 2	0 1	0 1
____-____-____-31	0 1	0 1	0 1	0 1	0 1	0 1	0 1 2 3 4	0 1 2 3	0 1 2 3	0 1 2 3	0 1	0 1	0 1 2	0 1	0 1

Rater Answer Form - Acids and Bases (Alien Recipe Version)

Rater Name: ______________ Date: August ___, 1994

Rater ID Number: ____________ Time: Start_____ End: _____

Student ID	Part 1			Part 2			Part 3	Part 4			
	A	B	C	A	B	C		A	B	C	D
_____-_____-_____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8 9	0 1	0 1 2	0 1	0 1
_____-_____-_____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8 9	0 1	0 1 2	0 1	0 1
_____-_____-_____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8 9	0 1	0 1 2	0 1	0 1
_____-_____-_____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8 9	0 1	0 1 2	0 1	0 1
_____-_____-_____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8 9	0 1	0 1 2	0 1	0 1
_____-_____-_____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8 9	0 1	0 1 2	0 1	0 1
_____-_____-_____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8 9	0 1	0 1 2	0 1	0 1
_____-_____-_____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8 9	0 1	0 1 2	0 1	0 1
_____-_____-_____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8 9	0 1	0 1 2	0 1	0 1
_____-_____-_____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8 9	0 1	0 1 2	0 1	0 1
_____-_____-_____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8 9	0 1	0 1 2	0 1	0 1
_____-_____-_____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8 9	0 1	0 1 2	0 1	0 1
_____-_____-_____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8 9	0 1	0 1 2	0 1	0 1
_____-_____-_____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8 9	0 1	0 1 2	0 1	0 1
_____-_____-_____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8 9	0 1	0 1 2	0 1	0 1
_____-_____-_____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8 9	0 1	0 1 2	0 1	0 1
_____-_____-_____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8 9	0 1	0 1 2	0 1	0 1
_____-_____-_____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8 9	0 1	0 1 2	0 1	0 1
_____-_____-_____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8 9	0 1	0 1 2	0 1	0 1
_____-_____-_____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8 9	0 1	0 1 2	0 1	0 1
_____-_____-_____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8 9	0 1	0 1 2	0 1	0 1
_____-_____-_____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8 9	0 1	0 1 2	0 1	0 1

Rater Answer Form - Acids and Bases (Alien Text Version)

Rater Name: ____________________ **Date: August ___, 1994**

Rater ID Number: ________________ **Time: Start______ End ______**

Student ID	Part 1 A	Part 1 B	Part 2 A	Part 2 B	Part 3	Part 4 A	Part 4 B	Part 4 C	Part 4 D
____-____-____-33	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8	0 1	0 1 2	0 1	0 1
____-____-____-33	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8	0 1	0 1 2	0 1	0 1
____-____-____-33	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8	0 1	0 1 2	0 1	0 1
____-____-____-33	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8	0 1	0 1 2	0 1	0 1
____-____-____-33	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8	0 1	0 1 2	0 1	0 1
____-____-____-33	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8	0 1	0 1 2	0 1	0 1
____-____-____-33	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8	0 1	0 1 2	0 1	0 1
____-____-____-33	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8	0 1	0 1 2	0 1	0 1
____-____-____-33	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8	0 1	0 1 2	0 1	0 1
____-____-____-33	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8	0 1	0 1 2	0 1	0 1
____-____-____-33	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8	0 1	0 1 2	0 1	0 1
____-____-____-33	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8	0 1	0 1 2	0 1	0 1
____-____-____-33	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8	0 1	0 1 2	0 1	0 1
____-____-____-33	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8	0 1	0 1 2	0 1	0 1
____-____-____-33	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8	0 1	0 1 2	0 1	0 1
____-____-____-33	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8	0 1	0 1 2	0 1	0 1
____-____-____-33	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8	0 1	0 1 2	0 1	0 1
____-____-____-33	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8	0 1	0 1 2	0 1	0 1
____-____-____-33	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8	0 1	0 1 2	0 1	0 1
____-____-____-33	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8	0 1	0 1 2	0 1	0 1
____-____-____-33	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8	0 1	0 1 2	0 1	0 1
____-____-____-33	0 1	0 1	0 1	0 1	0 1 2 3 4 5 6 7 8	0 1	0 1 2	0 1	0 1

Rater Answer Form - Acids and Bases (Alien Part 5 - All Versions)

Rater Name: ____________________ **Date: August** ___, **1994**

Rater ID Number: ________________ **Time: Start**_____ **End**_____

Student ID	Part 5 A	Part 5 B	Part 5 C
_____-_____-_____-_____	0 1 2	0 1	0 1 2
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_____-_____-_____-_____	0 1 2	0 1	0 1 2
_____-_____-_____-_____	0 1 2	0 1	0 1 2
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_____-_____-_____-_____	0 1 2	0 1	0 1 2
_____-_____-_____-_____	0 1 2	0 1	0 1 2
_____-_____-_____-_____	0 1 2	0 1	0 1 2
_____-_____-_____-_____	0 1 2	0 1	0 1 2

10. Radiation

The radiation task was developed by Stanford University and the Far West Laboratory, and it was administered to ninth-grade students in 1994. This task and the rate of cooling task were derived from the Heat and Energy shell that contains two parts: (1) designing an experiment and (2) carrying out an experiment.

In this task, students explore the relationship between color and heat absorption by measuring the temperature change of water in differently colored test tubes as they are exposed to a heat lamp. In the first part students "mess around," trying out the equipment in groups and learning to think analytically and work cooperatively. Then they design an experiment individually to test the relationship between colors and rate of heat absorption. This includes identifying factors (water volume, distance from light, etc.) to be controlled, fully describing the experimental procedure, designing a chart to record the results, and defining the unit of measurement to apply to the dependent variable.

In the second part, students perform a predesigned experiment in groups to test the relationship; then they analyze the results individually. This requires application of an equation relating heat, temperature change, and volume to the experimental results to infer a solution to the practical question that motivated the experiment.

Only the design and analysis steps (which are carried out individually) are scored.

The components of the radiation task will be found on the following pages:

SHELLS FOR 10TH GRADE PHYSICAL SCIENCE PERFORMANCE TASKS

Designing An Experiment

Subtask Number	Description	Purpose	Important Skills Required	Comments/Explanations	Performance Record
1	DAY 1:Overview by teacher	Assist student understanding of performance test	Listening	Teacher describes sequence of 2-day test [4-day if Carrying Out an Experiment is to follow] and the difference between a performance test and a paper-and- pencil test	none
2	Presentation of problem	Assist student understanding of task, motivation	Listening	Teacher poses problem to students	none
3	Demonstration of equipment	Familiarize student with equipment available for carrying out task	Listening, familiarity with basic laboratory equipment	Teacher demonstrates equipment and describes potential uses	none
4	Pre-experiment group discussion	Encourage student thought and discussion about task	Ability to share ideas and listen to others' ideas, recording, summarizing	Students discuss four questions in small groups and record brief responses from each group member	Group answer sheet
5	Messing around	Improve student measurement techniques used to solve original problem; stimulate reflection preparatory to design task on day 2	Assembling equipment, reading thermometer, thinking analytically, working cooperatively		Group answer sheet
6	Presentation of guidelines for clear answers	Familiarize students with task expectations	Reading, referring to chart	A set of 5 guiding questions and 9 reminders are presented in chart format	None

Subtask Number	Description	Purpose	Important Skills Required	Comments/Explanations	Performance Record
7	DAY 2: Presentation of problem	Motivate and orient students to task	Listening	Teacher again describes the situation ("cover story") and the question students are to try to answer	none
8	Restatement of purpose	Assess student understanding of task	Writing	Student is asked to restate purpose of experiment	Experimental Design Answer Sheet, question 1
9	Question regarding control factors	Encourage student consideration of control in experimental design	Understanding of scientific method	Students are asked to list 3 measurements or quantities that must remain constant across trials	Experimental Design Answer Sheet, question 2
10	Description of procedure	Assess student ability to design an experiment	Understanding of scientific method, writing, describing appropriate use of equipment to solve problem given	Student is asked to write a detailed description of an experimental procedure, clearly enough that another student could follow it	Experimental Desgin Answer Sheet, question 3
11	Data Chart Design	Assess student understanding of data collection and recording	Organizing data, constructing charts	Student is asked to design a data chart to be used to record data from the experiment s/he has designed	Experimental Design Answer Sheet, question 4
12	Rate units	Assess student understanding of units used to express measurement of rate	Understanding of "rate," knowledge of units used to experess rate	Student is asked to define the units used to express the measurement of rate in the experiment s/he has designed	Experimental Design Answer Sheet, question 5

Carrying Out an Experiment

Subtask Number	Description	Purpose	Important Skills Required	Comments/ Explanations	Performance Record
1	DAY 1:Overview by teacher	Assist student understanding of performance test	Listening	Teacher describes sequence of 2-day test and the difference between a performance test and a paper-and-pencil test [Overview abbreviated if Designing an Experiment was just completed]	none
2	Presentation of problem	Assist student understanding of task, motivation	Listening	Teacher poses problem to students	none
3	Demonstration of equipment	Familiarize student with equipment to be used in carrying out task	Listening, familiarity with basic laboratory equipment	Teacher introduces and labels equipment	none
4	Scripted Experiment	Engage students in effective group laboratory activity	Assembling and using equipment, following instructions, thinking analytically, working cooperatively in groups	Students follow "activity cards" providing step- by-step instructions for conducting trials using three materials	Sample Data Sheet
5	DAY 2: Presentation of guidelines for clear answers	Familiarize students with task expectations	Reading, referring to chart	A set of 5 guiding questions and 9 reminders are presented in chart format	None
6	Graphing	Assess graphing ability	Constructing graphs (choosing scales, labeling axes, reading data table, plotting points, completing line graph)	Students graph selected data from Class Data Sheet, with only a grid provided	Completed Graph (Experimental Analysis Answer Sheet, Question 1
7	Graph Interpretation	Assess interpretation of graphs and tables	Reading graphs and tables, writing	Students answer questions comparing rate of cooling for three trials	Experimental Analysis Answer Sheet, Question 2

Subtask Number	Description	Purpose	Important Skills Required	Comments/Explanations	Performance Record
8	Calculation	Assess student application of algebraic formula	Translation of prose statement into algebraic formula, substitution of data into equation, arithmetic calculation, tabular recording of results	Students calculate and compare a derived quantity for each of the three trials. Results are entered in a table	Experimental Analysis Answer Sheet, Question 3
9	Interpretation	Assess student understanding of experiment and ability to interpret findings and draw conclusions	Reading and interpreting graphs and tables, understanding scientific method, writing	Student answers a series of questions probing understanding of "rate," what was observed in experiment, possible explanations for observed differences across trials, answer to problem initially posed ("cover story"), and justification for answer	Experimental Analysis Answer Sheet, questions 4-9

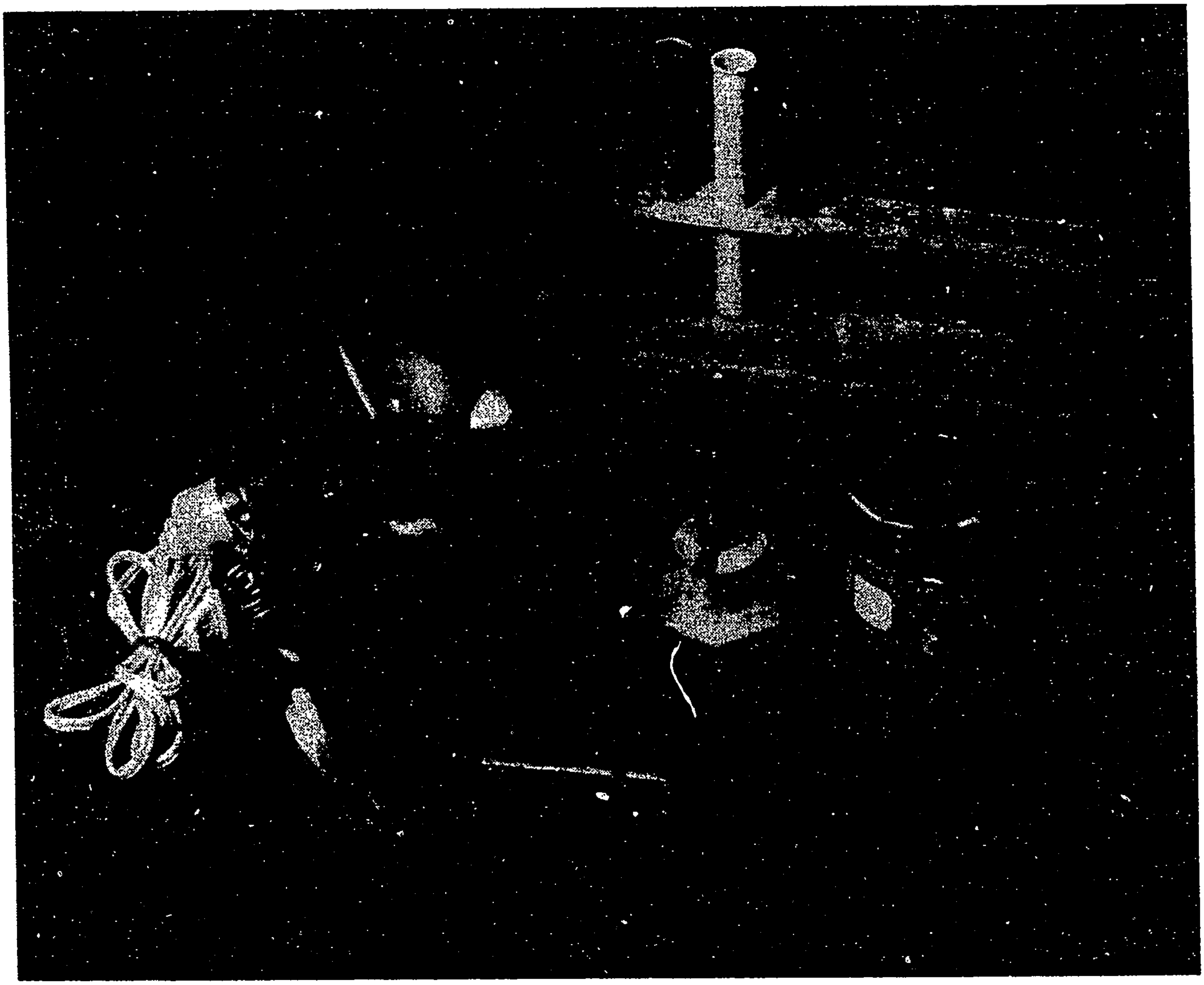

Figure 12—Equipment for Radiation

DO NOT WRITE ON THIS PAGE

Radiation Performance Assessment
"MESSING AROUND"
Group Activity Card

The Sunshine Construction Company has asked you, as skilled science students, for information on the following problem:

Find a way to accurately measure how quickly an object painted a certain color heats up.

To investigate this problem, your group will be able to use the following materials:

Your group should have the following materials:	Your teacher will supply *the entire class* with the following materials:
• 1 Group Answer Sheet • 1 Celsius thermometer • 1 watch with second hand or stopwatch • 1 250-ml beaker • 1 400-ml beaker • 1 100-ml graduated cylinder • 1 test tube, painted blue • 1 test tube rack • 1 support stand & rod (ring stand) • 1 Reflector Lamp • 1 150-watt light bulb • 1 metric ruler	• water supply from faucet or labeled "Tap Water" • safety goggles for every student • paper towels (or other drying material)

FACILITATOR: *Before the group "messes around" with the equipment,* ask each group member (including yourself) the questions below. Be sure that everyone answers a question before going on to the next question. Start with a different person each time you go to a new question. Your group's RECORDER will take *brief* notes on the **GROUP ANSWER SHEET**.

1. What ideas do you have about how to measure how quickly the water heats up, using the equipment provided?
2. Do you think it will make a difference *where* you hold the end of the thermometer in the test tube?
3. How will you measure the *rate* of heating for the test tube? What *units* will you use?
4. Do you think that the rate of heating will depend on how much water is in the test tube? If so, how?

After answering these questions, guide your group in "messing around" with the equipment. Try out as many of the group's ideas as possible.

CAUTION:
Avoid touching the Reflector Lamp and the light bulb—they can get very hot!!! Also, if water hits the surface of the heated light bulb it may explode.

KEEP WATER AWAY FROM THE LAMP AND WEAR SAFETY GOGGLES *AT ALL TIMES!!!*

Δ

Radiation Performance Assessment
EXPERIMENTAL DESIGN
Student Instruction Sheet

You have recently been presented with a situation which can be approached scientifically. The Sunshine Construction Company has asked you, as a skilled science student, for information on the following problem:

Given a choice of buildings painted in one of three different colors, which color would do the best job of keeping the inside of the building from heating up quickly under the hot sun?

As explained earlier, the equipment available to investigate this problem includes:

1. 1 Reflector Lamp with a 150-watt light bulb
2. 3 test tubes, each painted a different color.
3. 1 test tube rack
4. tap water
5. 1 Celsius thermometer
6. 1 stopwatch (or similar timepiece to measure seconds)
7. additional materials: beakers, 1 graduated cylinder, 1 metric ruler, paper towels, and safety goggles.

Your task is to design an experiment to solve the problem using this equipment. ***You must explain how to use the equipment to measure the rate of heating of water placed in the test tubes.***

When instructed to do so, answer the questions on your **Student Answer Sheet.** Δ

When the time is up, turn in *this sheet* and your **Student Answer Sheet** as directed by your instructor.

Radiation Performance Assessment
EXPERIMENTAL DESIGN
Student Answer Sheet

TEAR OFF THIS PAGE.

Read through this table carefully, and use it to help you write answers that are CLEAR, PRECISE, and COMPLETE.

GUIDING QUESTION(S)	CAUTIONS	
CLEAR	WRITING	DRAWING
• Can another student understand what you've written or drawn?	• Answer in complete sentences when appropriate	• Avoid crowding • Erase completely
PRECISE	WRITING	DRAWING
• Did you respond *directly* to the question? • Are your measurements *exact?*	• Do not use words like "it" unless you're sure the reader knows what "it" refers to • Specify units	• Use labels and arrows • Specify units or dimensions
COMPLETE	WRITING	DRAWING
• Did you respond to *all* parts of the question? • Have you included *all* the parts normally expected (e.g., of a graph)?	• Assume that the reader knows only what you tell him or her	• Label/identify all parts and pieces

Radiation Performance Assessment
EXPERIMENTAL DESIGN
Student Answer Sheet

Write your answers to the questions below in ***pencil.***
Feel free to go back and change your responses within the time allowed.
Make sure all your answers are CLEAR, PRECISE, and COMPLETE!

You have been given the following problem:

Given a choice of buildings painted in one of three colors, which color would do the best job of keeping the inside of the building from heating up quickly under the hot sun?

The previous task gave you the opportunity to "mess around" with some equipment. For this task, you need to design an experiment that uses the equipment on the **Student Instruction Sheet** to measure the ***RATE OF HEATING* for *Color A, Color B, and Color C.*** Your experiment should include *at least one experimental trial* for each color.

1. In your own words, what would you be trying to find out in such an experiment? In other words, what would be the experiment's *purpose?*

2. List at least three measurements or quantities you would be sure to *keep the same for each trial* in your experiment. (These are factors that you need to control or standardize.)

a)

b)

c)

others:

3. Think about how you would do a science experiment to investigate this problem. In the space below, write a set of directions that another student could follow to carry out your experiment. In addition to the guidelines given on the first page of this answer sheet, your directions should:

- begin with a list/illustrations of the *materials* you will use
- be a series of *numbered* steps (after the materials section)
- have enough *detail* so that another student would know *exactly* what to do without extra help
- include *illustrations* where you feel they are appropriate

MATERIALS:

Continue your answer to Question 3 in the space below as needed.
Otherwise, GO ON TO QUESTION 4 ON THE NEXT PAGE.

4. Draw a chart or table that you could use to record the data from your experiment. Make sure this chart or table allows you to organize the data so that you could compare the three different colors to one another.

5. In what **units** does your experiment measure rate of heating?

_______________ per _______________

Δ

Radiation Performance Assessment
RADIATION EXPERIMENT
Group Activity Card

The Sunshine Construction Company has asked you, as skilled science students, for information on the following problem:

Given a choice of buildings painted in one of three different colors, whi .n color would do the best job of keeping the inside of the building from heating up quickly under the hot sun?

To investigate this problem, your group will be able to use the following materials:

Your group should have the following materials:	Your teacher will supply *the entire class* with the following materials:
• **Student Data Sheets** (1 for each group member) • 1 Celsius thermometer • 1 watch with second hand or stopwatch • 1 250-ml beaker • 1 400-ml beaker • 1 100-ml graduated cylinder • 3 test tubes, each a different color • 1 test tube rack • 1 support stand & rod (ring stand) • 1 Reflector Lamp • 1 150-watt light bulb • 1 metric ruler • 3 or more textbooks (to make platform for raising test tube rack)	• water supply from faucet or labeled "Tap Water" • safety goggles for every student • paper towels (or other drying material)

Read through *all* of the instructions BEFORE beginning this experiment!

Complete the following steps when directed to do so by your instructor:

1. *Without any water*, arrange the Reflector Lamp (containing a 150-watt light bulb), support stand & rod, test tube rack with any single test tube, and textbooks as shown in Figure 1. Use textbooks to make sure that the *middle* of the test tube is at the same height as the *center* of the light bulb. So that they are not affected by the light from the bulb, keep the test tubes and the thermometer *behind* the lamp when not in use. Plug in the lamp, turn it on and off to make sure it works. Be careful not to shine the light in anyone's eyes and do not look directly into the bulb.

   Leave the lamp turned off for now.

CAUTION:
Avoid touching the Reflector Lamp and the light bulb—they can get very hot!!! Also, if water hits the surface of the heated light bulb it may explode.
KEEP WATER AWAY FROM THE LAMP AND WEAR SAFETY GOGGLES *AT ALL TIMES!!!*

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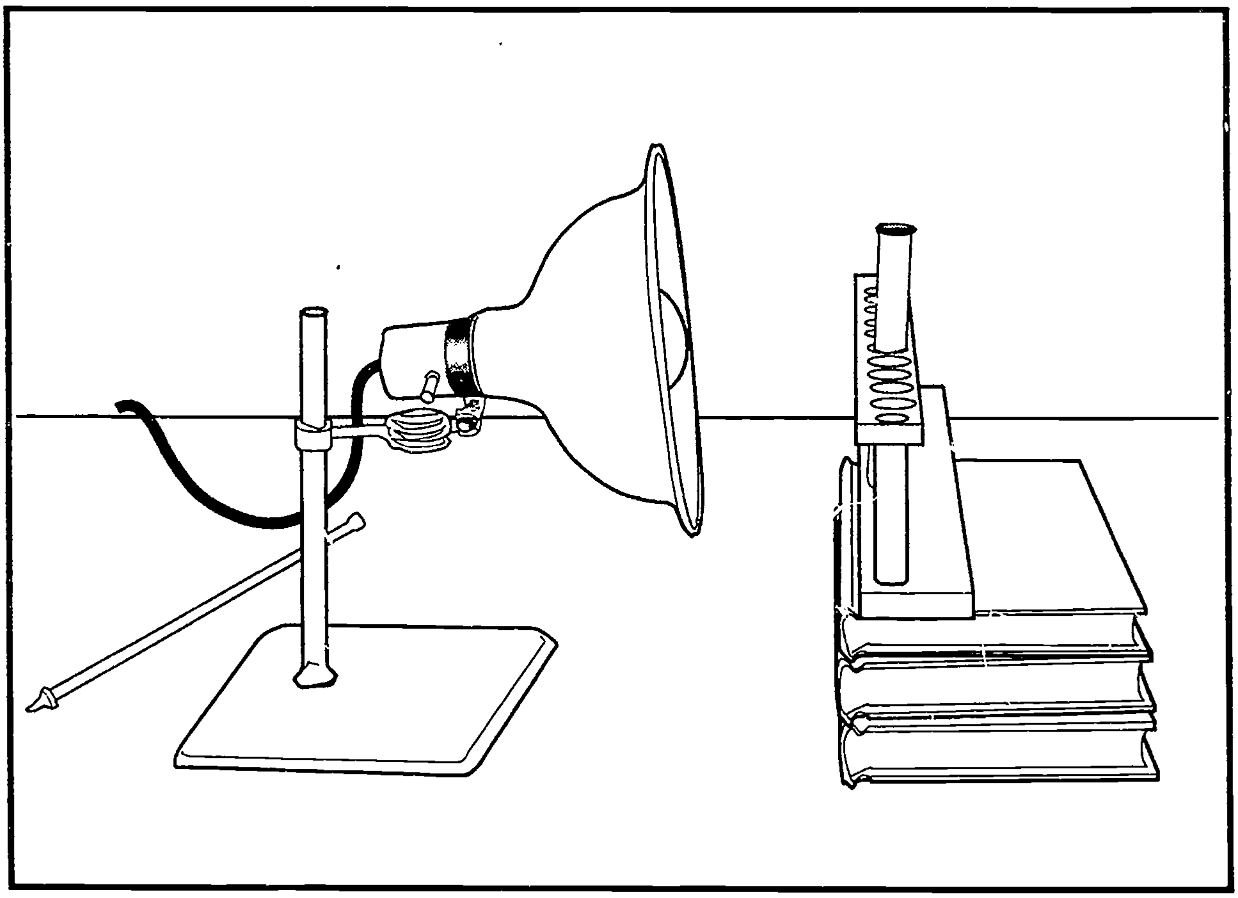

Figure 1.

RANDP178-2-0495

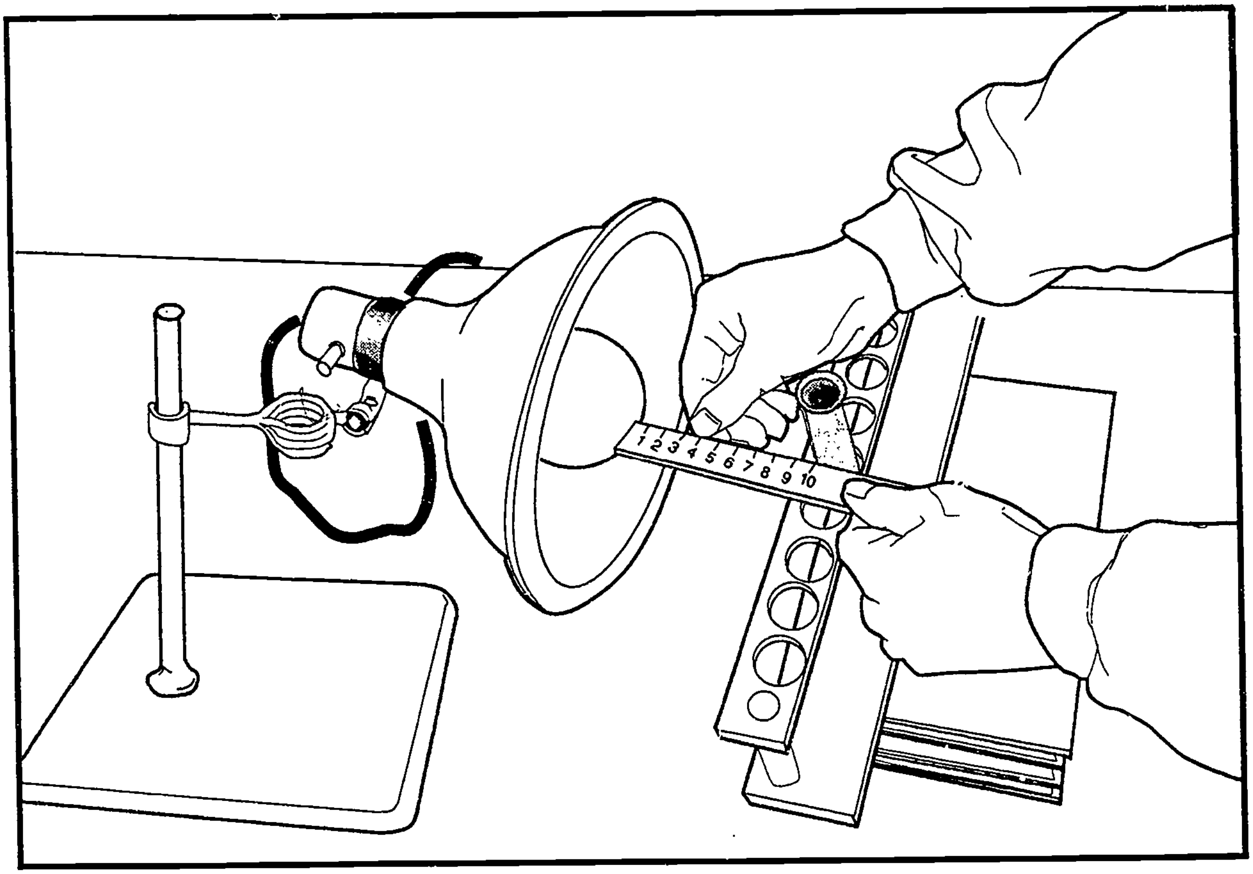

Figure 2.

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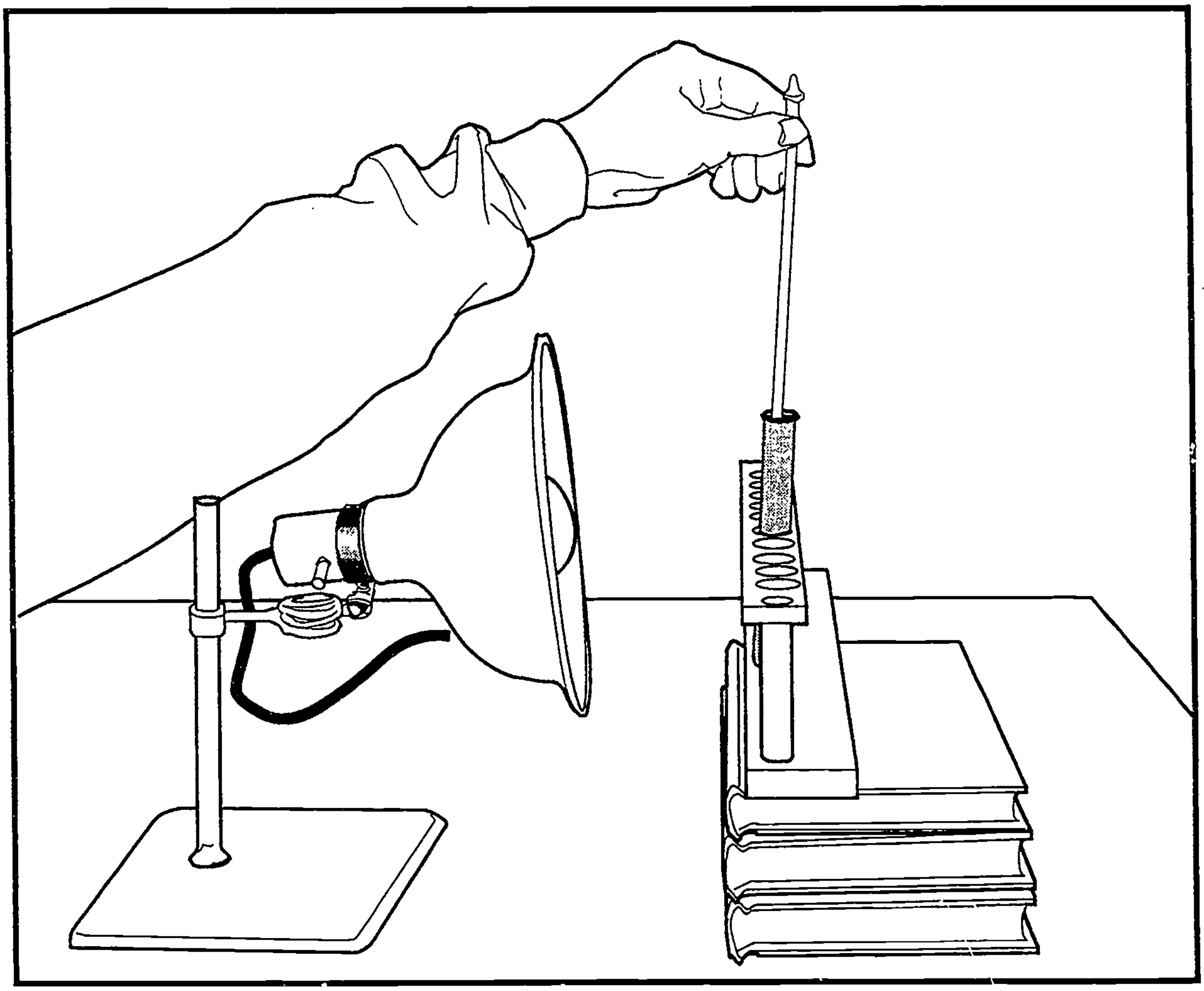

Figure 3.

TRIAL 1

2. Place the yellow test tube in the *center* of the test tube rack (there should be no other test tubes in the rack). Measure 20 ml of room temperature water into this test tube.

3. With the **Reflector Lamp** ***off***, move the test tube rack so that there is a distance of 10 cm between the outside edge of the test tube and the outside edge of the round part of the light bulb (see Figure 2).

4. Place the thermometer in this test tube and record the temperature of the water in the appropriate space of your **Task 2A.4 Student Data Sheet.**

5. Turn the **Reflector Lamp *on*** and begin timing. Reaching from behind or to the side of the Reflector Lamp (see Figure 3), read the temperature every 30 seconds and record this information in the appropriate spaces.

6. Turn the **Reflector Lamp *off*.** Empty the water from the test tube and place it upside down at either end of the test tube rack.

7. Calculate the total change in temperature and record this number in the appropriate space.

TRIAL 2

8. Place the blue test tube in the *center* of the test tube rack. Measure 20 ml of room temperature water into this test tube.

9. With the **Reflector Lamp *off*,** check to make sure that the distance between the outside edge of the test tube and the outside edge of the round part of the light bulb is still 10 cm (see Figure 2). Reposition the test tube rack if necessary.

10. Place the thermometer in this test tube and record the temperature of the water in the appropriate space of your **Task 2A.4 Student Data Sheet.**

11. Repeat steps 5-7 as in Trial 1.

TRIAL 3

12. Place the gray test tube in the *center* of the test tube rack. Measure 20 ml of room temperature water into this test tube.

13. With the **Reflector Lamp *off*,** check to make sure that the distance between the outside edge of the test tube and the outside edge of the round part of the light bulb is still 10 cm (see Figure 2). Reposition the test tube rack if necessary.

14. Place the thermometer in this test tube and record the temperature of the water in the appropriate space of your **Task 2A.4 Student Data Sheet.**

15. Repeat steps 5-7 as in Trial 1. Δ

When the time is up, turn in this sheet and your **Student Data Sheet**, and clean and return your equipment as directed by your instructor.

Radiation Performance Assessment
Student Data Sheet

Table 1. Heating Trial Temperatures

TIME (in seconds)	TRIAL 1 Yellow (in °C)	TRIAL 2 Blue (in °C)	TRIAL 3 Gray (in °C)
0 (starting)			
30			
60			
90			
120			
150			
180			
210			
240			
270			
300			

Table 2. Summary

	TRIAL 1 Yellow (in °C)	TRIAL 2 Blue (in °C)	TRIAL 3 Gray (in °C)
Total change in temperature (°C)			
Rate of Heating (°C per minute)			

Δ

Radiation Performance Assessment
EXPERIMENTAL ANALYSIS
Sample Data Sheet

Note: The results on this **Sample Data Sheet** are from an experiment similar to the one you performed, except that measurements were taken every 60 seconds instead of every 30 seconds.

Table 1. Heating Trial Temperatures

TIME (in seconds)	**TRIAL 1** Yellow water volume V=20 ml	**TRIAL 2** Blue water volume V=20 ml	**TRIAL 3** Gray water volume V=20 ml	**TRIAL 4** Red water volume V=20 ml	**TRIAL 5** Red water volume V=10 ml	**TRIAL 6** Red water volume V=20 ml
0 (starting)	°C	°C	°C	°C	°C	°C
60	°C	°C	°C	°C	°C	°C
120	°C	°C	°C	°C	°C	°C
180	°C	°C	°C	°C	°C	°C
240	°C	°C	°C	°C	°C	°C
300	°C	°C	°C	°C	°C	°C

Table 2. Total Change in Temperatures (ΔT)

TRIAL 1 Yellow	**TRIAL 2** Blue	**TRIAL 3** Gray	**TRIAL 4** Red	**TRIAL 5** Red	**TRIAL 6** Red
°C	°C	°C	°C	°C	°C

Radiation Performance Assessment
EXPERIMENTAL ANALYSIS
Student Answer Sheet

TEAR OFF THIS PAGE.

Read through this table carefully, and use it to help you write answers that are CLEAR, PRECISE, and COMPLETE.

GUIDING QUESTION(S)	CAUTIONS	
CLEAR	WRITING	DRAWING
• Can another student understand what you've written or drawn?	• Answer in complete sentences when appropriate	• Avoid crowding • Erase completely
PRECISE	WRITING	DRAWING
• Did you respond *directly* to the question? • Are your measurements *exact?*	• Do not use words like "it" unless you're sure the reader knows what "it" refers to • Specify units	• Use labels and arrows • Specify units or dimensions
COMPLETE	WRITING	DRAWING
• Did you respond to *all* parts of the question? • Have you included *all* the parts normally expected (e.g., of a graph)?	• Assume that the reader knows only what you tell him or her	• Label/identify all parts and pieces

Radiation Performance Assessment
EXPERIMENTAL ANALYSIS
Student Answer Sheet

Before starting, make sure you have the following materials: 1 **Sample Data Sheet**, 1 ruler, 1 ordinary pencil, and 1 set of colored pencils (minimum 3).

1. Graph the results of **Trials 1, 2, and 3** ***only*** as given on the **Sample Data Sheet**. Create a *line graph* on the grid below. Your graph should display data from these three trials on a *single set of axes*. Data from each trial should be displayed in a different color. **YOU WILL BE GIVEN 15 MINUTES TO COMPLETE YOUR GRAPH.** (If you finish your graph sooner, go on to the next question.)

Title: ____

2. Looking at your graph, describe how the *rate of heating* changed during each trial. Remember that your answers should be clear, precise, and complete.

a) Trial 1:

b) Trial 2:

c) Trial 3:

3. Temperature is measured in °C. Heat is measured in *calories*. One calorie is the energy gained or lost by 1 ml of liquid water when its temperature rises or falls by 1°C. For example, if 2 ml of water rose 3°C in temperature (ΔT=3°C), then 6 calories would be gained. If 5 ml of water fell 2°C (ΔT=-2°C), then 10 calories would be lost. In the box below, write a formula for heat energy gained in calories.

> If **Q** is the heat energy gained in calories, and
>
> **ΔT** is the total change in temperature in °C
> (see Table 2 on your Sample Data Sheet for an example of ΔT), and
>
> **V** is the volume in ml, then
>
> **Q** = ______________________
>
> (complete the equation using ΔT and V)

Using this formula, calculate the *heat* gained by the water in the test tube for each of the 6 trials. Be sure to calculate the *total* heat gained during the five minutes when measurements were taken for each trial.

Complete the following table as you do your calorie calculations:

Table 3. Heat gain calculations

Trial	Color	V	ΔT	Q
1	Yellow			
2	Blue			
3	Gray			
4	Red			
5	Red			
6	Red			

4. a) Which of the six trials showed the greatest *total change in temperature?*

   b) What was the amount of that temperature change?

5. a) Which of the six trials showed the greatest *heat gain?*

   b) What was the amount of that heat gain?

6. What is a possible reason why *different* temperature changes were observed in Trials 4 and 6?

7. a) Name two trials that you could compare to investigate the effect of **volume of water in the test tube** on the rate of heating.

   __________ and __________

   b) Why did you choose those two trials?

8. From the sample data, what can you conclude about the effect of volume on rate of heating? Remember that your answer should be clear, precise, and complete.

9. a) Now answer this question:

Given a choice of buildings painted in one of three different colors, which color would do the best job of keeping the inside of the building cool under the hot sun - yellow, blue, or gray?

____

b) What evidence is there that this color would be the best at keeping the inside of the building cool? Be specific. Consider information on the **Sample Data Sheet**, your graph, and the tables on this **Answer Sheet**. You may use graphs or illustrations as part of your answer. Remember that your answer should be clear, precise, and complete.

Δ

Radiation Design
Scoring Rubric

#1 (pg.2) 1.1 **Purpose** (States ANY purpose)
The student restates in his or her own words either (1) the purpose of the experiment (for example, "to find the paint that would keep a building coolest") or (2) what the experiment is trying to determine (for example, "which paint will keep the water the coolest" or "what are the rates of heat gain") Note: Almost always give credit unless only a conclusion is specified

#2 (pg.2) 2.1 **Volume**
- lists "volume of water" or "amount of water" **or**
- measurement such as "20 ml" (ml alone also okay)

2.2 **Distance from test tubes to lamp**
- measurement such as "10 cm" or "6 in away" okay
- units alone (cm. or in.) also okay, "same place" not okay

2.3 **Times at which measurements are taken** ("time", interval measurement such as "30 sec.", or units such as "seconds" also okay.)

2.4 **Other** (Variables must be possible confounding factors-- for example, "initial temperature" or "temperature", "depth of thermometer" or "wattage of light bulb". Items copied directly from the materials list are not acceptable

#3 (pg. 3-4) (For scoring this question, information clearly conveyed in figures, tables, diagrams, etc., in answer to question 3 should be credited.)

3.1 **Materials - lists or illustrates 2 or more** (any list okay)

3.2 **Steps - 2 or more are numbered**. Lists any series of at least two numbered steps for procedure ("first, second, etc.", "a, b, etc." okay)

#3 (p3-4) 3.3 **Rate- takes temperature at specified time intervals or records time for temperature to increase to a certain value** for at least one tube
- procedure measures temperature as a function of time (e.g. "measure temperature, (after 5 minutes) measure again", "take temperature every 30 seconds") or measures time as a function of temperature (e.g. "write down how long it takes for temperature to increase 10 degrees")
- must clearly imply use of a thermometer with statements such as "take temperature", "check thermometer", "put thermometer in tube...check" ("see how much it heated up" is also okay)
- temperature checked only at the end of a time interval is acceptable only if three tubes are heated and measured simultaneously

3.4 **Tubes - tests 2 or more different colored**
Procedure performed for different colored test tubes, either sequentially or simultaneously (general reference okay, for example, "change the test tube color" or "do the same with the other test tubes"). Just mentioning three tubes but measuring none is not okay.

(Note on variable measurement and control:
The student may choose to add replication trials or trials in which confounding factors are treated as variables (e.g., "use 10 ml of water for the first trial, 20 ml for the second") Give credit where appropriate for specifying amounts, but do not give credit for using same procedure unless the important variables are also controlled in other trials.)

3.5 **Volume - specifies or controls amount of liquid in tube**
Procedure must explicitly measure volume **or** assert that the same amount of water must be used for each test tube; responses such as "fill the test tubes" are not acceptable.

3.6 **Distance from lamp specified or controlled**
- distance measurement given (e.g. 10 cm.) **or**
- student asserts that the distance must be the same for each tube **or**
- all colors are tested at the same time with one lamp

3.7 **Uses the same procedure for all tubes**
- same measurements specified for each tube **or**
- measurements are made for the first tube and instructions are to "do the same with the other test tubes"
- simultaneous testing is okay.

#4 (pg. 5) 4.1 **All 3 tubes (colors)** labeled on table

4.2 **Time** (intervals or to criterion)
- at least 2 headings with "sec" or "min" **or**
- criterion heading (e.g. "temperature after 5 minutes") (unit of time is needed: "start" and "end" not okay)

4.3 **Temperature in chart title or heading** (can be indicated by title or heading with the words "temperature", "degrees" or "deg. C")

#5 (pg. 5) 5.1 **Temperature in first blank** (degrees, Celsius, or degrees Celsius) ("temperature", "heat" or "5 degrees" not okay)

5.2 **Time in second blank** (minutes, seconds, or time interval such as "30 seconds")

Rater Answer Form - Radiation: Design

Rater Name: ______________________________ Date: April _____, 1994

Rater ID Number _________________ Starting Time: ___________ AM/PM

Instructions: Circle the number of points awarded for each question.

Student ID Number	Purpose	Constants				Procedures							Table			Formula	
		Vol	Dist	Time	Other	Mat	Stps	Rate	Tube	Vol	Dist	Same	3 Tube	Time	Temp	Temp	Time
____-____-____-22	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1
____-____-____-22	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1
____-____-____-22	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1
____-____-____-22	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1
____-____-____-22	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1
____-____-____-22	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1
____-____-____-22	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1
____-____-____-22	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1
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____-____-____-22	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1
____-____-____-22	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1

Radiation Analysis
Scoring Rubric

#1 (pg. 2)

1a Graph- Axes

1.1 Labeled (1 point for "time," 1 point for "temperature")

1.2 Appropriate units specified
- "seconds" or "minutes" for time
- "degrees Celsius., "degrees", " " or "Celsius" for temperature.)

1.3 Equal Intervals (if origin is 0,0 and there is a gap in numbering for an axis, no credit for that axis unless a break in the graph is correctly indicated)

1.4 Time on x-axis (indicated by "time", "seconds" **or** numbering of axis with "60, 120, 180"

1b Graph-Trials

1.5 Plotted and identified
- any points plotted
- key, labels, or colors must be used to permit identification of trial by letter, number or fabric

1.6 Line graph drawn rather than bar graph (points must be connected in conventional manner)

1.7 Single set of axes used for all 3 trials (give credit for single set of axes labeled but slightly staggered plots drawn)

1.8 All 6 data points plotted (or 6 bars) per trial

1c Graph-Results

1.9 Proper slope (all plots indicate heating)

1.10 0 sec.=25 degrees Celsius for all three trials. (If equal intervals are used, can infer the 0 on the x axis, don't need "0" or "start" to give credit for 0=25 degrees Celsius.)

1.11 End points in order: 1>3>2 (if separate graphs are used but not identified, can assume that trial 1 is on the left)

#2

2a (pg. 3) Trials

2a.1 Pattern (1,2,3,2,2)
- Numbers must be used
- Entire pattern must be described
- Rate must be indicated (" degrees Celsius/min." is best; "degrees for each time interval" is acceptable)

- Rates of cooling for minutes 1-5 of trial 1, in degrees Celsius/min. are 1,2,3,2,2
- Must refer to time (& temp). If mentioned first time, then can infer in next two, but some interval must be indicated.

2a.2 Summary- mean rate, total change or comparison of rate, speed or amount of temperature change

makes an accurate (but can be approximate) statement about one of these features of trial 1:

- average change (e.g. "it decreased 2 degrees per minute")
- total change (e.g. "it changed 10 degrees", endpoints alone are not sufficient)
- comparison to another trial in speed amount or rate (e.g. "the temperature decreased more slowly than trial 2" (Note: if comparison is made to a specific other trial, give summary credit for both trials)

2b (pg. 3)

2b.1 Pattern (2,3,2,4,4)

- Numbers must be used
- Temperature list alone not sufficient
- Entire pattern must be described
- Rate must be indicated ("degrees Celsius/min." is best; "degrees for each time interval" is acceptable)
- Rates of radiation for minutes 1-5 of trial 2, in degrees Celsius/min are 2,3,2,4,4

2b.2 Summary- mean rate, total change or comparison of rate, speed or amount of temperature change
makes an accurate (but can be approximate) statement about one of these features of trial 1:
• average change (e.g. "it decreased 3 degrees per minute")
• total change (e.g. "it changed 15 degrees", endpoints alone are not sufficient)
• comparison to another trial in speed, amount, or rate (e.g. "the temperature increased faster (than trial 1 can be inferred))
(Note: if comparison is made to a specific other trial, give summary credit for both trials)

2c (pg. 3)

2c.1 Pattern (1,3,3,3,2)
• Numbers must be used
• Temperature list alone not sufficient
• Entire pattern must be described
• Rate must be indicated (" degrees Celsius/min." is best; "degrees for each time interval" is acceptable)
• Rates of cooling for minutes 1-5 of trial 3, in degrees Celsius./min. are 1,3,3,3,2

2c.2 Summary- mean rate, total change or comparison of rate, speed or amount of temperature change
makes an accurate (but can be approximate) statement about one of these features of trial 3
• average change (e.g. "it decreased 2 degrees per minute")
• total change (e.g. "it changed 12 degrees", endpoints alone are not sufficient)
• comparison (e.g. "the temperature change was in the middle"
(Note: if comparison is made to a specific other trial, give summary credit for both trials)

#3 (pg. 4)

3.1 Equation: Q = V x T (can also multiply by 1 (specific heat of water))
Q = V x T (no /)is not acceptable
3.2 V column (all 6 correct values)
3.3 T column (all 6 correct values)
3.6 Q column (5 of 6 correct values)
column Q has at least five of the six calorie calculations correct

#4

4a (pg. 5)

4a.1 Trial 5 identified as trial with the greatest change in temperature

4b.1 (pg. 5)

4b.1 "18" written (with or without degrees Celsius or degrees)
4b.2 degrees Celsius or degrees used as unit

#5

5a (pg. 5)
5a.1 Trial 2 identified as trial with greatest heat loss

5b (pg. 5)
5b.1 "300" written (with or without "calories")
5b.2 Calories used as units

#6 (pg. 5)
6.1 Reason given for rate difference
- Examples: random error, difference in ice water temperature, different air temperatures
- reason must not be volume or fabric

#7

7a (pg. 5)
7a.1 Trials 4&5 or Trials 5&6 used to observe the effect of volume

7b (pg. 5)
7b.1 Volume varies- student states that cans have different volumes

7b.2 Other variables remain the same
- states that the conditions are the same except for volume **or**
- asserts that the two trials have identical color conditions (red)

#8 (pg. 6)
8.1 Volume effect
directly or indirectly indicates that the rate of heating is greater for smaller volumes or less for larger volumes

#9

9a (pg. 6)
9a.1 Yellow tube is best

#9b (pg. 6)
9b.1 Evidence from experiment to support choice
Notes:
1. general reference okay, for example: "Yellow kept the water the coolest" or "yellow got less heat."
2. Indirect reference okay, for example, "because the temperature increased the least"
3. Do not give credit if experimental evidence not mentioned (no credit for only "Yellow was proven to be the best" or "Yellow is the lightest color")

9b.2 Specific data
Answer cites numbers from Tables 1 or 2 (or numbers that can be derived from the tables, such as calorie calculations or graph points.)

Rater Answer Form - Radiation Analysis

Rater Name: ____________________ **Date: April** _____ **1994**
Rater ID Number _______ **Student ID:** _____-_____-_____**-24**

1a. Graph - Axes (1 for each axis)

Labeled (time and temp)	0 1 2
Appropriate units specified (seconds, minutes, degrees)	0 1 2
Equal intervals	0 1 2
Time on X-axis	0 1

1b. Graph - Trials

Plotted and identified (1 per tube)	0 1 2 3
Line graph	0 1
Single set of axes	0 1
All 6 data points plotted for each trial	0 1

1c. Graph - Results

Proper slope	0 1
0 seconds = 25 degrees	0 1
End points in order: 2 > 3 > 1	0 1

2.Trials (Summary = mean, total D; compare speed, rate, amount)

Trial #1 -	Pattern (1,2,3,2,2)	0 1
	Summary	0 1
Trial #2 -	Pattern (2,3,2,4,4)	0 1
	Summary	0 1
Trial #3 -	Pattern (1,3,3,3,2)	0 1
	Summary	0 1

3. Formula and Table

Equation Q = V * DT	0 1
V column (6 correct values)	0 1
DT column (6 correct values)	0 1
Q column (5 of 6 correct values)	0 1

V	DT	Q
20	10	200
20	15	300
20	12	240
20	13	260
10	18	180
20	14	280

4. Greatest change: 1 = Tr.5, 1 = 18, 1 = degrees 0 1 2 3

5. Greatest heat: 1 = Tr.2, 1 = 300, 1 = calories 0 1 2 3

6. Reason: 1 = e.g., chance, variation in air temp, color, paint thickness
0 1

7. Compare volume:

1 = Tr.4/5 or 5/6	0 1
1 = Volume varies	0 1
1 = Other variables remain the same (e.g. color)	0 1

8. Volume effect: 1 = faster heating with smaller volumes 0 1

9. Which tube:

Yellow	0 1
Evidence from experiment	0 1
Specific data - relevant numbers cited	0 1

11. Rate of Cooling

The rate of cooling task was developed by Stanford University and the Far West Laboratory, and it was administered to ninth-grade students in 1994. The Heat and Energy shell was used for the rate of cooling task and the radiation task (see Section 10).

In this task, students measure the insulation properties of different fabrics by immersing cans of water covered with fabric "socks" in an ice bath and measuring temperature changes. In the first part, students "mess around," trying out the equipment in groups and learning to think analytically and work cooperatively. Then they design an experiment individually to test the effects of the fabrics on heat loss. This includes identifying factors (water volume, initial water temperature, etc.) to be controlled, fully describing the experimental procedure, designing a chart to record the results, and defining the unit of measurement to apply to the dependent variable.

In the second part, students perform a predesigned experiment in groups to test the fabrics; then they analyze the results individually. This requires application of an equation relating heat, temperature change, and volume to the experimental results to infer a solution to the practical question that motivated the experiment.

As in the radiation task, only the design and analysis steps (which are carried out individually) are scored.

The components of rate of cooling task will be found on the following pages:

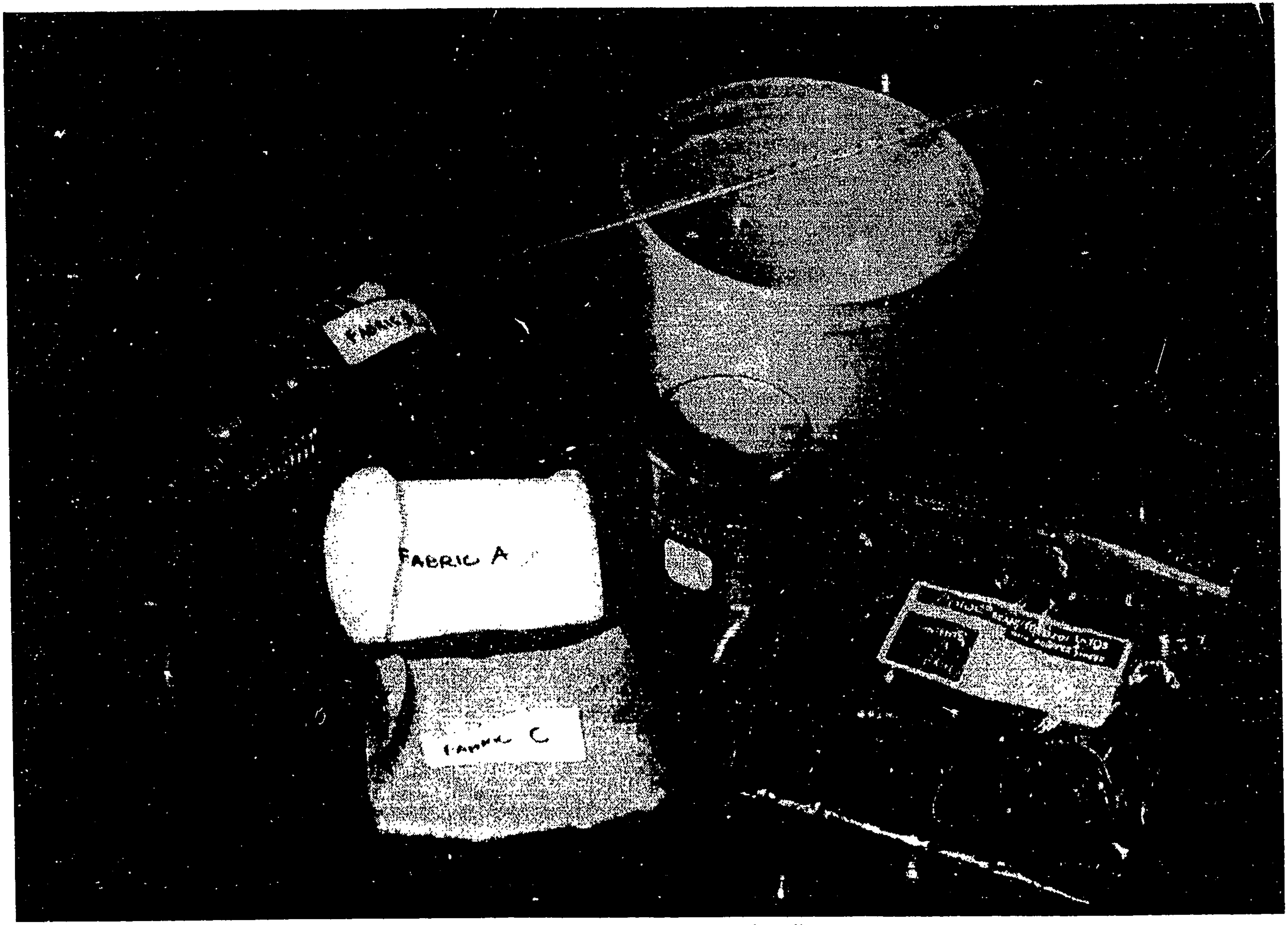

Figure 13—Equipment for Rate of Cooling

Rate of Cooling Performance Assessment
"MESSING AROUND"
Group Activity Card

The Alpine Outdoor Clothing Company has asked you, as skilled science students, for information on the following problem:

Find a way to accurately measure how quickly heat is lost through a fabric.

To investigate this problem, your group will be able to use the following materials:

Your group should have the following materials:	Your teacher will supply *the entire class* with the following materials:
• 1 Group Answer Sheet • 1 Celsius thermometer • 1 watch with second hand or stopwatch • 1 250-ml beaker • 1 large plastic container with lid, <u>containing</u>: • 1 standard soup size metal can with top lid removed • 1 fabric "sock," labeled Fabric B • 1 sandwich size re-sealable plastic bag • 2 rubber bands	• water supply labeled "Warm Water" • water supply from faucet or labeled "Tap Water" • ice (cubes or crushed) • safety goggles for every student • paper towels (or other drying material)

FACILITATOR: *Before the group "messes around" with the equipment,* ask each group member (including yourself) the questions below. Be sure that everyone answers a question before going on to the next question. <u>Start with a different person each time you go to a new question</u>. Your group's RECORDER will take *brief* notes on the **GROUP ANSWER SHEET**.

1. What ideas do you have about how to measure heat lost through a fabric, using the equipment provided?
2. How will you keep the fabric "sock" dry?
3. How will you measure the *rate* of cooling for the fabric? What *units* will you use?
4. Do you think that the rate of cooling will depend on how much hot water is in the can? If so, how?

After answering these questions, guide your group in "messing around" with the equipment. Try out as many of the group's ideas as possible. Remember that the fabric "socks" MUST STAY DRY. Δ

Rate of Cooling Performance Assessment
"MESSING AROUND"
Group Answer Sheet

RECORDER: Write your name in the heading of this paper. Write each group member's name (including your own) in the boxes below, one name per box. Take *brief* notes on each person's response to the questions in the table. Write these comments in INK (do not go back and change them!). You do not need to write in complete sentences.

	Name:	Name:	Name:	Name:
What ideas do you have about how to measure heat lost through a fabric, using the equipment provided?				
How will you keep the fabric "sock" dry?				
How will you measure the *rate* of cooling for the fabric? What *units* will you use?				
Do you think that the rate of cooling will depend on how much hot water is in the can? If so, how?				

Rate of Cooling Performance Assessment
"MESSING AROUND"
Group Answer Sheet, page 2

RECORDER: In the space below, write down any notes you think are important as your team "messes around" with the equipment. You may use **pen or pencil** (you may change these notes if you wish). You do not need to write in complete sentences. Δ

Rate of Cooling Performance Assessment
EXPERIMENTAL DESIGN
Student Instruction Sheet

You have recently been presented with a situation that can be approached scientifically. The Alpine Outdoor Clothing Company has asked you, as a skilled science student, for information on the following problem:

Given a choice of jackets made from three different materials, which one would do the best job of slowing down the loss of body heat?

As explained earlier, the equipment available to investigate this problem includes:

1. 1 soup size metal can
2. 3 different fabric "socks" that can be fitted over the can, one at a time, labeled Fabric A, Fabric B, and Fabric C
3. 1 large container
4. tap water and ice
5. warm water (at or above 37°C)
6. 1 Celsius thermometer
7. 1 stopwatch (or similar timepiece to measure seconds)
8. additional materials: 1 250-ml beaker, 1 sandwich size re-sealable plastic bag, 2 rubber bands, paper towels, safety goggles.

Your task is to design an experiment to solve the problem using this equipment. ***You must explain how to use the equipment to measure the rate of cooling of warm water placed in the can.*** Remember that the fabric "socks" **MUST STAY DRY.**

When instructed to do so, answer the questions on your **Student Answer Sheet.**
Δ

When the time is up, turn in *this sheet* and your **Student Answer Sheet** as directed by your instructor.

Rate of Cooling Performance Assessment
EXPERIMENTAL DESIGN
Student Answer Sheet

TEAR OFF THIS PAGE.

Read through this table carefully, and use it to help you write answers that are CLEAR, PRECISE, and COMPLETE.

GUIDING QUESTION(S)	CAUTIONS	
CLEAR	WRITING	DRAWING
• Can another student understand what you've written or drawn?	• Answer in complete sentences when appropriate	• Avoid crowding • Erase completely
PRECISE	WRITING	DRAWING
• Did you respond *directly* to the question? • Are your measurements *exact?*	• Do not use words like "it" unless you're sure the reader knows what "it" refers to • Specify units	• Use labels and arrows • Specify units or dimensions
COMPLETE	WRITING	DRAWING
• Did you respond to *all* parts of the question? • Have you included *all* the parts normally expected (e.g., of a graph)?	• Assume that the reader knows only what you tell him or her	• Label/identify all parts and pieces

Rate of Cooling Performance Assessment
EXPERIMENTAL DESIGN
Student Answer Sheet

Write your answers to the questions below in ***pencil.***
Feel free to go back and change your responses within the time allowed.
Make sure all your answers are CLEAR, PRECISE, and COMPLETE!

You have been given the following problem:

Given a choice of jackets made from three different materials, which one would do the best job of slowing down the loss of body heat?

The previous task gave you the opportunity to "mess around" with some equipment. For this task, you need to design an experiment that uses the equipment on the **Student Instruction Sheet** to measure the ***RATE OF COOLING* for *Fabric A, Fabric B, and Fabric C.*** Your experiment should include *at least one experimental trial* for each fabric.

1. In your own words, what would you be trying to find out in such an experiment? In other words, what would be the experiment's *purpose?*

2. List at least three measurements or quantities you would be sure to *keep the same for each trial* in your experiment. (These are factors that you need to control or standardize.)

a)

b)

c)

others:

3. Think about how you would do a science experiment to investigate this problem. In the space below, write a set of directions that another student could follow to carry out your experiment. In addition to the guidelines given on the first page of this answer sheet, your directions should:

- begin with a list/illustrations of the *materials* you will use
- be a series of *numbered* steps (after the materials section)
- have enough *detail* so that another student would know *exactly* what to do without extra help
- include *illustrations* where you feel they are appropriate

MATERIALS:

Continue your answer to Question 3 in the space below as needed.
Otherwise, GO ON TO QUESTION 4 ON THE NEXT PAGE.

4. Draw a chart or table that you could use to record the data from your experiment. Make sure this chart or table allows you to organize the data so that you could compare the three different fabrics to one another.

5. In what **units** does your experiment measure rate of cooling?

_______________ per _______________

Δ

Rate of Cooling Performance Assessment
RATE OF COOLING EXPERIMENT
Group Activity Card

The Alpine Outdoor Clothing Company has asked you, as skilled science students, for information on the following problem:

Given a choice of jackets made from three different materials, which one would do the best job of slowing down the loss of body heat?

To investigate this problem, your group will be able to use the following materials:

Your group should have the following materials:	Your teacher will supply *the entire class* with the following materials:
• **Student Data Sheets** (1 for each group member) • 1 Celsius thermometer • 1 watch with second hand or stopwatch • 1 250-ml beaker • 1 large plastic container with lid, containing: • 1 standard soup size metal can with top lid removed • 3 different fabric "socks," labeled Fabric A, Fabric B, & Fabric C • 1 sandwich size re-sealable plastic bag • 2 rubber bands	• water supply labeled "Warm Water" (heated above 37°C) • water supply from faucet or labeled "Tap Water" • ice (cubes or crushed) • safety goggles for every student • paper towels (or other drying material)

Read through *all* of the instructions BEFORE beginning this experiment!

Complete the following steps when directed to do so by your instructor:

TRIAL 1

1. Wrap the *empty* can in Fabric A, place it in the plastic bag (with the opened end facing up), and put the two rubber bands around the bag to hold it in place. Make the bag fit tightly, so there is no air space between the bag and the can (see Figure 1 on page 2).

2. Add roughly equal amounts of ice and water from a faucet ("Tap Water") to the large plastic container so that it is nearly full (see Figure 2 on page 2).

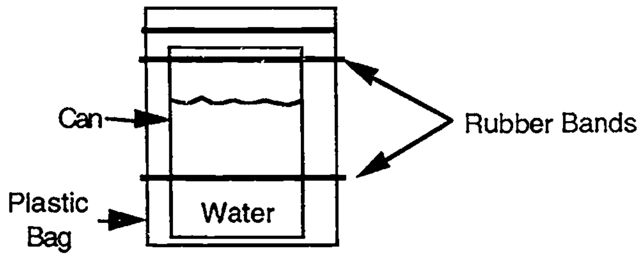

Figure 1

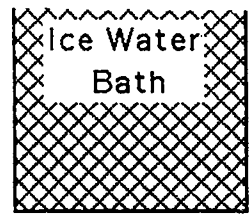

Figure 2

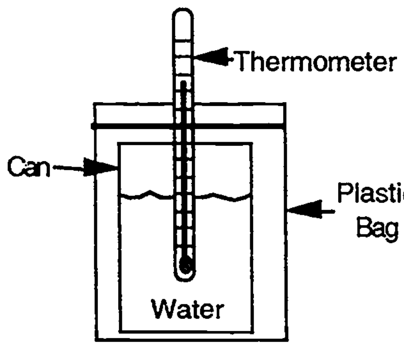

Figure 3

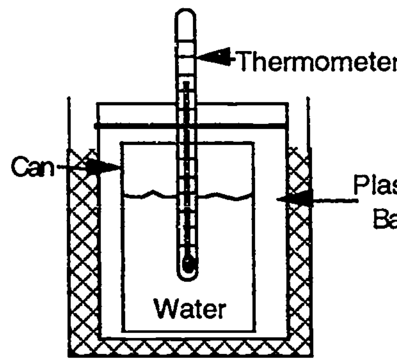

Figure 4

3. Place 200 ml of "Warm" water into the can wrapped in Fabric A.

4. Place the thermometer in the can and seal the top of the bag around it (see Figure 3 above).

5. Place the setup shown in Figure 3 into your ice water bath (see Figure 4 above). Be careful not to let any of the water from the ice water bath get inside the plastic bag.

6. Check the temperature of the warm water. When it is 37°C (between 35°C and 39°C is acceptable), record this as your starting temperature on your **Student Data Sheet.**

7. Read the temperature every 30 seconds for five minutes (300 seconds) and record this information on your **Student Data Sheet** as you go.

8. Calculate the total change in temperature and the rate of cooling and record these numbers in the appropriate spaces on your **Student Data Sheet.**

9. Remove the setup from the ice water bath. Remove the thermometer, water, and fabric "sock" from the can. If necessary, dry the inside of the plastic bag.

TRIAL 2

10. Repeat step 1 using *Fabric B.*

11. Place 200 ml of "Warm" water into the can now wrapped in Fabric B.

12. Place the thermometer in the can and seal the top of the bag around it (see Figure 3 on page 2).

13. Place the setup shown in Figure 3 into your ice water bath (see Figure 4 on page 2). Be careful not to let any of the water from the cold water bath get inside the plastic bag.

14. Watch the temperature, and try to begin timing just when the temperature reaches 37°C (between 35°C and 39°C is acceptable). Record the starting temperature in the appropriate space on your **Student Data Sheet.**

15. Repeat steps 7 through 9 as done in Trial 1.

TRIAL 3

16. Repeat step 1 using *Fabric C.*

17. Place 200 ml of "Warm" water into the can now wrapped in Fabric C.

18. Place the thermometer in the can and seal the top of the bag around it (see Figure 3 on page 2).

19. Place the setup shown in Figure 3 into your ice water bath (see Figure 4 on page 2). Be careful not to let any of the water from the ice water bath get inside the plastic bag.

18. Watch the temperature, and try to begin timing just when the temperature reaches 37°C (between 35°C and 39°C is acceptable). Record the starting temperature in the appropriate space on your **Student Data Sheet.**

19. Repeat steps 7 through 9 as done in Trial 1. Δ

When the time is up, turn in this sheet and your **Student Data Sheet**, and clean and return your equipment as directed by your instructor.

Rate of Cooling Performance Assessment
Student Data Sheet

Table 1. Cooling Trial Temperatures

TIME (in seconds)	TRIAL 1 Fabric A (in °C)	TRIAL 2 Fabric B (in °C)	TRIAL 3 Fabric C (in °C)
0 (starting)			
30			
60			
90			
120			
150			
180			
210			
240			
270			
300			

Table 2. Summary

	TRIAL 1 Fabric A (in °C)	TRIAL 2 Fabric B (in °C)	TRIAL 3 Fabric C (in °C)
Total change in temperature (°C)			
Rate of Cooling (°C per minute)			

Δ

Rate of Cooling Performance Assessment
EXPERIMENTAL ANALYSIS
Sample Data Sheet

Note: The results on this **Sample Data Sheet** are from an experiment similar to the one you performed, except that measurements were taken every 60 seconds instead of every 30 seconds.

Table 1. Cooling Trial Temperatures

TIME (in seconds)	**TRIAL 1** Fabric A water volume V=200 ml	**TRIAL 2** Fabric B water volume V=200 ml	**TRIAL 3** Fabric C water volume V=200 ml	**TRIAL 4** No Fabric water volume V=200 ml	**TRIAL 5** No Fabric water volume V=50 ml	**TRIAL 6** No Fabric water volume V=200 ml
0 (starting)	°C	°C	°C	°C	°C	°C
60	°C	°C	°C	°C	°C	°C
120	°C	°C	°C	°C	°C	°C
180	°C	°C	°C	°C	°C	°C
240	°C	°C	°C	°C	°C	°C
300	°C	°C	°C	°C	°C	°C

Table 2. Total Change in Temperatures (ΔT)

TRIAL 1 Fabric A	**TRIAL 2** Fabric B	**TRIAL 3** Fabric C	**TRIAL 4** No Fabric	**TRIAL 5** No Fabric	**TRIAL 6** No Fabric
°C	°C	°C	°C	°C	°C

Rate of Cooling Performance Assessment
EXPERIMENTAL ANALYSIS
Student Answer Sheet

TEAR OFF THIS PAGE.

Read through this table carefully, and use it to help you write answers that are CLEAR, PRECISE, and COMPLETE.

GUIDING QUESTION(S)	CAUTIONS	
CLEAR	WRITING	DRAWING
• Can another student understand what you've written or drawn?	• Answer in complete sentences when appropriate	• Avoid crowding • Erase completely
PRECISE	WRITING	DRAWING
• Did you respond *directly* to the question? • Are your measurements *exact?*	• Do not use words like "it" unless you're sure the reader knows what "it" refers to • Specify units	• Use labels and arrows • Specify units or dimensions
COMPLETE	WRITING	DRAWING
• Did you respond to *all* parts of the question? • Have you included *all* the parts normally expected (e.g., of a graph)?	• Assume that the reader knows only what you tell him or her	• Label/identify all parts and pieces

Rate of Cooling Performance Assessment
EXPERIMENTAL ANALYSIS
Student Answer Sheet

Before starting, make sure you have the following materials: 1 **Sample Data Sheet**, 1 ruler, 1 ordinary pencil, and 1 set of colored pencils (minimum 3).

1. Graph the results of **Trials 1, 2, and 3 *only*** as given on the **Sample Data Sheet**. Create a *line graph* on the grid below. Your graph should display data from these three trials on a *single set of axes*. Data from each trial should be displayed in a different color. **YOU WILL BE GIVEN 15 MINUTES TO COMPLETE YOUR GRAPH.** (If you finish your graph sooner, go on to the next question.)

Title: ____

2. Looking at your graph, describe how the *rate of cooling* changed during each trial. Remember that your answers should be clear, precise, and complete.

   a) Trial 1:

   b) Trial 2:

   c) Trial 3:

3. Temperature is measured in °C. Heat is measured in *calories*. One calorie is the energy gained or lost by 1 ml of liquid water when its temperature rises or falls by 1°C. For example, if 2 ml of water rose 3°C in temperature (ΔT=3°C), then 6 calories would be gained. If 5 ml of water fell 2°C (ΔT=-2°C), then 10 calories would be lost. In the box below, write a formula for heat energy lost in calories.

> If **Q** is the heat energy lost in calories, and
>
> **ΔT** is the total change in temperature in °C
> (see Table 2 on your Sample Data Sheet for an example of ΔT), and
>
> **V** is the volume in ml, then
>
> **Q** = ______________________
>
> (complete the equation using ΔT and V)

Using this formula, calculate the *heat* lost by the water in the can for each of the 6 trials. Be sure to calculate the *total* heat lost during the five minutes when measurements were taken for each trial.

Complete the following table as you do your calorie calculations:

Table 3. Heat loss calculations

Trial	Fabric	V	ΔT	Q
1	A			
2	B			
3	C			
4	None			
5	None			
6	None			

4. a) Which of the six trials showed the greatest *total change in temperature?*

   b) What was the amount of that temperature change?

5. a) Which of the six trials showed the greatest *heat loss*?

   b) What was the amount of that heat loss?

6. What is a possible reason why *different* temperature changes were observed in Trials 4 and 6?

7. a) Name two trials that you could compare to investigate the effect of **volume of water in the can** on the rate of cooling.

   ____________ and ____________

   b) Why did you choose those two trials?

8. From the sample data, what can you conclude about the effect of volume on rate of cooling? Remember that your answer should be clear, concise, and complete.

9. a) Now answer this question:

   Given a choice of jackets made from three different materials, which one would do the best job of slowing down the loss of body heat - Fabric A, Fabric B, or Fabric C?

   ____

   b) What evidence is there that this fabric would be the best at slowing down the loss of body heat? Be specific. Consider information on the **Sample Data Sheet**, your graph, and the tables on this **Answer Sheet**. You may use graphs or illustrations as part of your answer. Remember that your answer should be clear, concise, and complete.

   Δ

Rate of Cooling Analysis
Scoring Rubric

#1 (pg. 2)

1a Graph- Axes

1.1 **Labeled** (1 point for "time", 1 point for "temperature")

1.2 **Appropriate units specified**
- "seconds" or "minutes" for time
- "degrees Celsius", "degrees", or "Celsius" for temperature.)

1.3 **Equal Intervals** (if origin is 0,0 and there is a gap in numbering for an axis, no credit for that axis unless a break in the graph is correctly indicated)

1.4 **Time on x-axis** (indicated by "time", "seconds" **or** numbering of axis with "60, 120, 180"

1b Graph-Trials

1.5 **Plotted and identified**
- any points plotted
- key, labels, or colors must be used to permit identification of trial by letter, number or fabric)

1.6 **Line graph** drawn rather than bar graph (points must be connected in conventional manner)

1.7 **Single set of axes** used for all 3 trials (give credit for single set of axes labeled but slightly staggered plots drawn

1.8 **All 6 data points plotted** (or 6 bars) per trial

1c Graph-Results:

1.9 **Proper slope** (all plots indicate cooling)

1.10 **0 sec.=37 deg. Celsius** for all three trials. (If equal intervals are used, can infer the 0 on the x axis, don't need "0" or "start" to give credit for 0=37 deg.)

1.11 **End points in order: 3>1>2** (if separate graphs are used but not identified, can assume that trial 1 is on the left)

#2a (pg. 3) Trials

2a.1 Pattern (1,1,1,1,1)
- Numbers must be used
- Entire pattern must be described
- Rate must be indicated (" degrees Celsius/min." is best; "degrees for each time interval" is acceptable)

• Rates of cooling for minutes 1-5 of trial 1, in deg Celsius./min. are 1,1,1,1,1 (rate is constant). (note: for this trial only, "it decreased 1 degree per minute" or "it was 1 degree per minute" is given credit for both summary and pattern information.)

2a.2 Summary- mean rate, total change or comparison of rate, speed or amount of temperature change

makes an accurate (but can be approximate) statement about one of these features of trial 1:

• average change (e.g. "it decreased 1 degree per minute")

• total change (e.g. "it changed 5 degrees", endpoints alone are not sufficient)

• comparison (e.g. "the temperature decreased more slowly than trial 2" (Note: if comparison is made to a specific other trial, give summary credit for both trials)

#2b (pg. 3)

2b.1 Pattern (2,1,2,1,1)

• Numbers must be used

• Entire pattern must be described

• Rate must be indicated (" degrees Celsius/min." is best; "degrees for each time interval" is acceptable)

• Rates of cooling for minutes 1-5 of trial 2, in degrees Celsius./min. are 2,1,2,1,1

2b.2 Summary- mean rate, total change or comparison of rate, speed or amount of temperature change

makes an accurate (but can be approximate) statement about one of these features of trial 1:

• average change (e.g. "it decreased 1 1/2 degrees per minute")

• total change (e.g. "it changed 7 degrees", endpoints alone are not sufficient)

• comparison (e.g. "the temperature decreased more slowly than trial 1" (Note: if comparison is made to a specific other trial, give summary credit for both trials)

#2c (pg. 3)

2c.1 Pattern (2,1,2,1,1)

• Numbers must be used

• Entire pattern must be described

• Rate must be indicated (" degrees Celsius/min." is best; "degrees for each time interval" is acceptable)

• Rates of cooling for minutes 1-5 of trial 3, in degrees Celsius/min. are 1,1,1,0,1

2c.2 Summary- mean rate, total change or comparison of rate, speed or amount of temperature change

makes an accurate (but can be approximate) statement about one of these features of trial 1:

• average change (e.g. "it decreased 1 degrees per minute")
• total change (e.g. "it changed 4 degrees", endpoints alone are not sufficient)
• comparison (e.g. "the temperature decreased more slowly than trial 2" (Note: if comparison is made to a specific other trial, give summary credit for both trials)

#3 (pg. 4) 3.1 **Equation: Q = V x T** (can also multiply by 1 (specific heat of water))
3.2 **V column** (all 6 correct values)
3.3 **T column** (all 6 correct values)
3.6 **Q column (5 of 6 correct values)**
column Q has at least five of the six calorie calculations correct

#4a (pg. 5) **4a.1 Trial 5 identified** as trial with the greatest change in temperature

#4b.1 (pg. 5) **4b.1 "20" written** (with or without degrees Celsius or degrees)
4b.2 degrees Celsius or degrees used as unit

#5a (pg. 5) **5a.1 Trial 4 identified** as trial with greatest heat loss

#5b (pg. 5) **5b.1 "3200" written** (with or without "calories"
5b.2 Calories used as units

#6 (pg. 5) 6.1 **Reason** given for rate difference
• Examples: random error, difference in ice water temperature, different air temperatures
• reason must not be volume or fabric

#7a (pg. 5) **7a.1 Trials 4&5 or Trials 5&6** used to observe the effect of volume

#7b (pg.5) **7b.1 Volume varies-** student states that cans have different volumes

7b.2 Same color
• asserts that the two trials have identical fabric conditions (no fabric) or
• states that the conditions are the same except for volume

#8 (pg. 6) 8.1 **Volume effect**
directly or indirectly indicates that the rate of cooling is greater for smaller volumes or less for larger volumes

#9a (pg. 6) **9a.1 Fabric C** is best

#9b (pg. 6) **9b.1 Evidence from experiment** to support choice

Notes:

1. general reference okay, for example: "fabric C kept the water the warmest" or "fabric C lost less heat"
2. Indirect reference okay, for example, "because the temperature decreased the least"
3. Do not give credit if experimental evidence not mentioned (no credit for only "fabric C was proven to be the best" or "fabric C is made of wool")

9b.2 Specific data

Answer cites numbers from Tables 1 or 2 (or numbers that can be derived from the tables, such as calorie calculations or graph points.)

Rater Answer Form - Cooling Analysis

Rater Name: ______________________________ **Date: April** _____ **1994**
Rater ID Number ________________ **Student ID:** _____-_____-_____**-24**

1a. Graph - Axes (1 for each axis)	
Labeled (time and temp)	0 1 2
Appropriate units specified (seconds, minutes, degrees)	0 1 2
Equal intervals	0 1 2
Time on X-axis	0 1
1b. Graph - Trials	
Plotted and identified (1 per fabric)	0 1 2 3
Line graph	0 1
Single set of axes	0 1
All 6 data points plotted for each trial	0 1
1c. Graph - Results	
Proper slope	0 1
0 seconds = 37 degrees	0 1
End points in order: 3 > 1 >2	0 1
2. Trials (Summary = mean, total D; compare speed, rate, amount)	
Trial #1 - Pattern (1,1,1,1,1)	0 1
Summary	0 1
Trial #2 - Pattern (2,1,2,1,1)	0 1
Summary	0 1
Trial #3 - Pattern (1,1,1,0,1)	0 1
Summary	0 1
3. Formula and Table	
Equation Q = V * DT	0 1
V column (6 correct values)	0 1
DT column (6 correct values)	0 1
Q column (5 of 6 correct values)	0 1

V	DT	Q
200	5	1000
200	7	1400
200	4	800
200	16	3200
50	20	1000
200	15	3000

4. Greatest change: 1 = Tr.5, 1 = 20, 1 = degrees	0 1 2 3
5. Greatest heat: 1 = Tr.4, 1 = 3200, 1 = calories	0 1 2 3
6. Reason: 1 = e.g., chance, variation in air or ice water temp, other...	0

7. Compare volume:		
1 = Tr.4/5 or 5/6	0	1
1 = Volume varies	0	1
1 = Other variables remain the same (e.g. no fabric)	0	1
8. Volume effect: 1 = faster cooling with smaller volumes	0	1
9. Which Fabric:		
Fabric C	0	1
Evidence from experiment	0	1
Specific data - quantities from table, curves on graph	0	1

Rate of Cooling Design
Scoring Rubric

#1 (pg.2) 1.1 **Purpose** (States **any** purpose)
The student restates in his or her own words either (1) the purpose of the experiment (for example, "to find the jacket fabric that would keep a person warmest " or (2) what the experiment is trying to determine (for example, "which fabric will keep the water the warmest" or "what are the rates of heat loss") Note: Almost always give credit unless only a conclusion is specified

#2 (pg.2) 2.1 **Volume**
- lists "volume of water" or "amount of water" **or**
- measurement such as "200 ml" (ml alone also okay)

2.2 **Initial temperature of water in can** ("water temperature" "temperature", or temperature measurement such as "37 deg. Celsius" also okay)

2.3 **Times at which measurements are taken** ("time", interval measurement such as "30 sec.", or units such as "seconds" also okay)

2.4 **Other** (Variables must be possible confounding factors-- for example, "initial temperature" or "temperature", "depth of thermometer" or "exact temperature of ice water bath". Items copied directly from the materials list are not acceptable.

#3 (pg 3-4) (For scoring this question, information clearly conveyed in figures, tables, diagrams, etc., in answer to question 3 should be credited.)

3.1 **Materials - lists or illustrates 2 or more** (any list okay)

3.2 **Steps - 2 or more are numbered**. Lists any series of at least two numbered steps for procedure ("first, second, etc.", "a, b, etc.." okay)

#3 (p3-4) 3.3 **Rate- takes temperature at specified time intervals or records time for temperature to increase to a certain value** for at least one can
- procedure measures temperature as a function of time (e.g. "measure temperature, (after 5 minutes) measure again", "take temperature every 30 seconds") or measures time as a function of temperature (e.g. "write down how long it takes for temperature to decrease 10 degrees")

must clearly imply use of a thermometer with statements such as "take temperature", "check thermometer", "put thermometer in can...check" ("see how much it heated up" is also okay)
temperature checked only at the end of a time interval is acceptable **only** if three tubes are heated and measured simultaneously

3.4 **Fabrics - tests 2 or more**

Procedure performed for different fabric-covered cans (general reference okay, for example, "change the fabric" or "do the same with the other fabrics"). Just mentioning three fabrics but measuring none is not okay.

(Note on variable measurement and control:
The student may choose to add replication trials or trials in which confounding factors are treated as variables (e.g., "use 50 ml of water for the first trial, 100 ml for the second") Give credit where appropriate for specifying amounts, but do not give credit for using same procedure unless the important variables are **also controlled** in other trials.)

3.5 **Volume - specifies or controls amount of liquid in tube**
Procedure must explicitly measure volume **or** assert that the same amount of water must be used for each fabric trial; responses such as "fill the can with water" are not acceptable.

3.6 **Initial temperature specified**
- 37 degree Celsius water used (not "at or above 37 deg. Celsius" **or**
- "body temperature" water specified

3.7 **Uses the same procedure for all fabrics**
- same measurements specified for each fabric **or**
- measurements are made for the first fabric and instructions are to "do the same with the other fabrics"

#4 (pg 5)

4.1 **All 3 fabrics** labeled on table

4.2 **Time** (intervals or to criterion)
- at least 2 headings with "sec" or "min" **or**
- criterion heading (e.g. "temperature after 5 minutes") (unit of time is needed: "start" and "end" not okay)

4.3 **Temperature in chart title or heading** (can be indicated by title or heading with the words "temperature", "degrees" or "degrees Celsius")

#5 (pg 5)

5.1 **Temperature in first blank** (degrees, Celsius, or degrees Celsius) ("temperature", "heat" or "5 degrees" not okay)

5.2 **Time in second blank** (minutes, seconds, or time interval such as "30 seconds")

Rater Answer Form - Rate of Cooling: Design

Rater Name: ______________________ Date: April _____, 1994

Rater ID Number ______________ Starting Time: __________ AM/PM

Instructions: Circle the number of points awarded for each question.

Student ID Number	Purpose	Constants				Procedures							Table			Formula	
		Vol	Temp	Time	Other	Mat	Steps	Rate	Fab	Vol	Temp	Same	3 Fab	Time	Temp	Temp	Time
____-____-____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1
____-____-____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1
____-____-____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1
____-____-____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1
____-____-____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1
____-____-____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1
____-____-____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1
____-____-____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1
____-____-____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1
____-____-____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1
____-____-____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1
____-____-____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1
____-____-____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1
____-____-____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1
____-____-____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1
____-____-____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1
____-____-____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1
____-____-____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1
____-____-____-32	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1

12. CLAS—Grade 5

This activity was developed by the California Learning Assessment System (CLAS) with input from the RAND project team; it was administered to students in grades 5 and 6 in 1993. The activity consisted of three hands-on tasks—representing earth, physical, and life science. The story line *Building a Science Museum* is used to coordinate the sciences in the three performance tasks. For *Building Materials*, students are presented with three rocks and a variety of tools and are asked to investigate the properties of the rocks to see which rock will be best for building tables and benches for a museum picnic area. For *Which Road Is Best?* students use a small dump truck, fishing weights, and washers to investigate the concepts of force and friction on two different road surfaces. For *Critter Museum*, students sort and classify plastic organisms and present rationales for their classifications. Students also have to provide information on how the animals might adapt to their environments.

The components of the CLAS—GRADE 5 tasks will be found on the following pages:

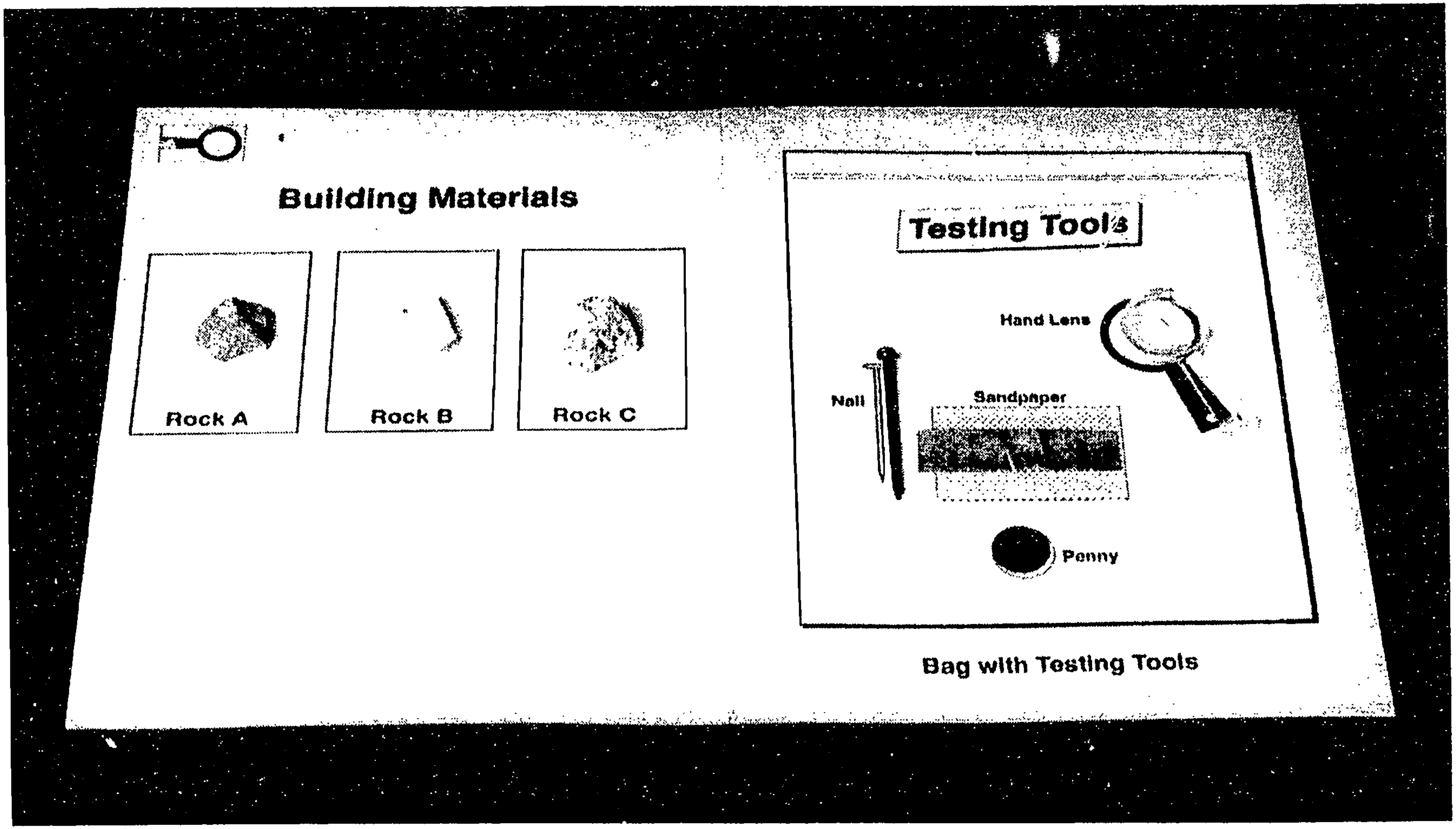

Figure 14—Equipment for CLAS Grade 5—Rocks

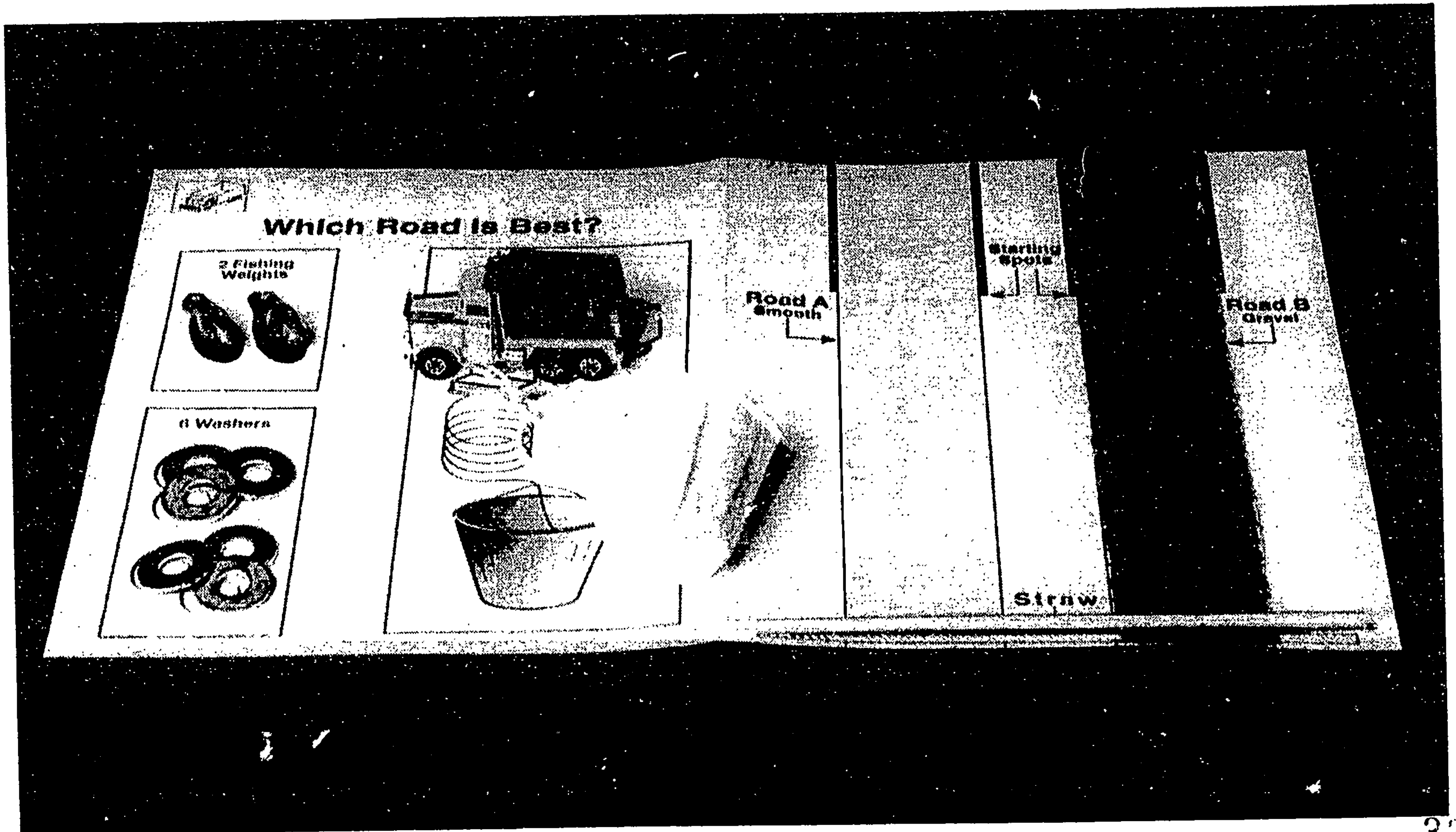

Figure 15—Equipment for CLAS Grade 5—Roads

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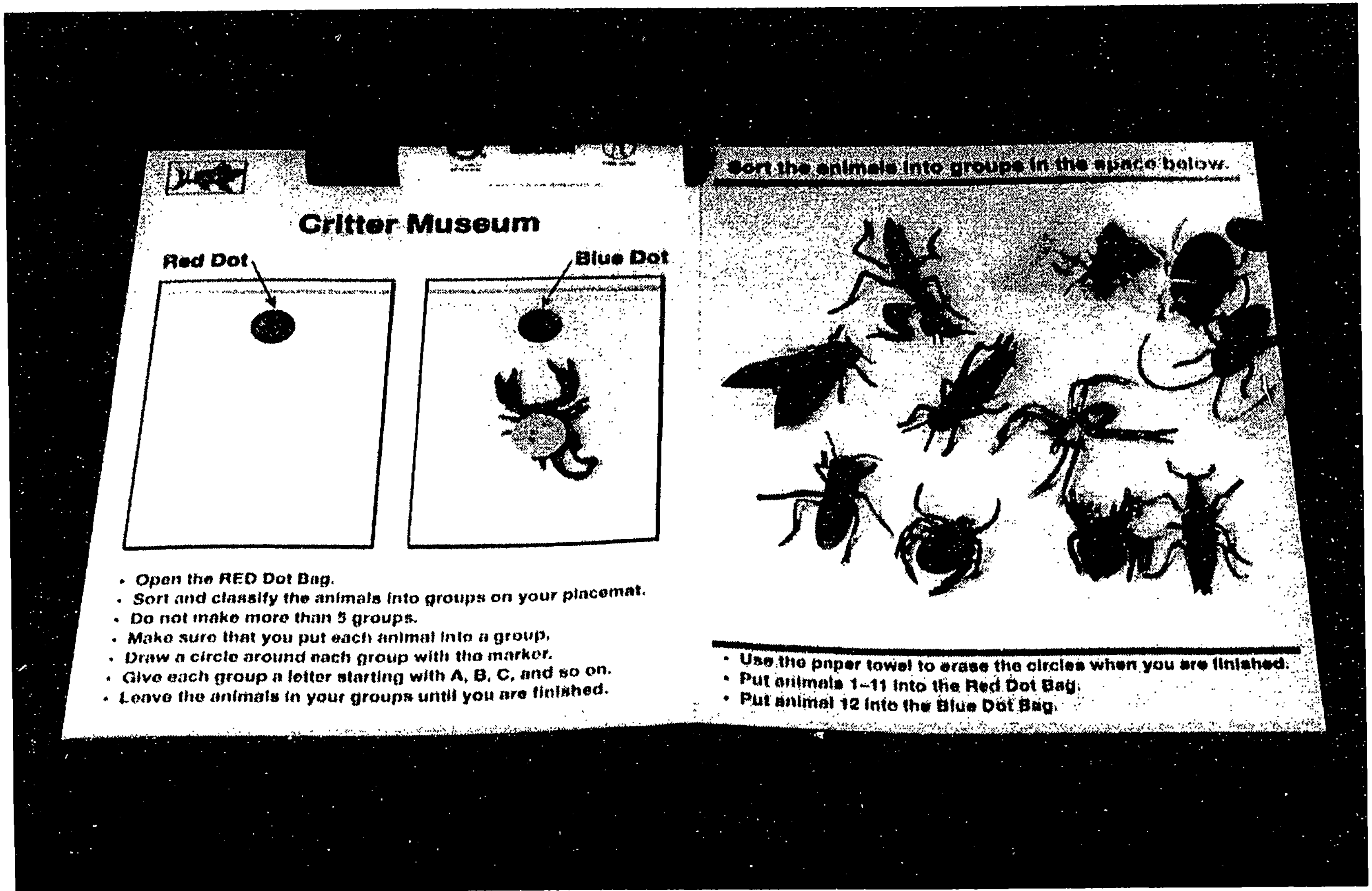


Figure 16—Equipment for CLAS Grade 5—Critters

332

333

Task page 1

Student ID Number____________

CALIFORNIA LEARNING ASSESSMENT SYSTEM

Spring 1993 Research Pilot Performance-Based Assessment Grade 5

Science

Student Answer Sheet

Directions:

You will be completing three performance tasks. Take this answer booklet with you as you go to each station. Write all of your observations, data, and results in this booklet.

Name: ____________________________________

Date: ______________ **Grade:** ______________

Sex: M or F **Date of Birth:** ______________

Teacher: ____________________________________

School: ____________________________________

Language spoken at home: ______________________

STOP

Task page 2

Directions

In the next 60 minutes you will conduct three science activities:

Task 1 – Building Materials

Task 2 – Which Road?

Task 3 – Critter Museum

In order to complete your activities, you will need to do the following:

- Do not repeat the activities. There is not enough time.
- Read and follow directions at each station.
- Spend 15 minutes at each station.
- Make careful observations.
- Carefully record and organize your data and results.
- Explain the reasons for your answers.
- Clean up the station when you are done and return the materials as you found them.
- If you break or use up any of the materials, be sure to let the teacher know.

Building a New Science Museum

You are part of a team working to build a new science museum for your community. The new science museum will include a nature-watch picnic area. Your team plans to use as many natural resources from the area as possible.

GO TO THE NEXT PAGE

Task page 3

Task 1 – "Building Materials"

Your team plans to use rocks from the area to create picnic tables and benches in the nature-watch picnic area. They found 3 rock samples that they would like to use. Since these rocks are part of the natural environment, they can be worn down by wind, rain, running water, and physical abuse. Your job is to choose the best rock that will last for the longest period of time under these conditions.

Directions:

- Using your hand lens, observe your 3 rocks.
- In the chart below, describe what each rock looks like.
- Include 3 features of each rock in your description.

1.

	Descriptions
Rock A	
Rock B	
Rock C	

GO TO NEXT PAGE

Task page 4

2. Based on your observations, which of these 3 rocks (**A**, **B**, or **C**) would be best for building the tables and benches?

Rock ________

Explain why____

____

____

Directions:

- Look at the tools in **Bag #1**.
- Use the tools in **Bag #1** to test your rock samples
- You may use 1, 2, or all 3 tools on each rock.
- For each rock, describe which tools you used and tell what happened to the rocks when you used the tools.
- Record your results in the chart below.

3.

	Tools and Results
Rock A	
Rock B	
Rock C	

GO TO NEXT PAGE

Task page 5

4. What are some of the other things you could do to the rocks to determine which one would last the longest? Explain why.

____

____

____

____

5. Using your results, which rock (**A**, **B**, or **C**) would you recommend to use to build the benches and tables?

Rock ______________

Explain why ______________________________

____

____

____

6. How can the weather wear down the rock benches and tables over time? Explain how.

____

____

____

____

____

____

____

____

GO TO NEXT PAGE

Task 2 – "Which Road Is Best?"

Heavy rains caused a landslide in the picnic area of the new science museum. A dump truck will be used to remove this extra soil and rocks.

There are 2 roads to the picnic area.

Road A is a paved road.

Road B is a dirt road.

Your job is to decide which road is the best to use.

Make sure that your station looks like this picture before you start.

GO TO NEXT PAGE

Task page 7

Directions:

Look at the picture below. Set up your materials for **Trial 1** and **Trial 2** on **Road A** in the same way.

GO TO NEXT PAGE

Task page 8

1.

Trial 1	Trial 2
Make sure your box is at the edge of the table. Put the truck in the starting spot on **Road A.** Put the string through the slot with the cup hanging over the edge of the table. Carefully add paper clips one at a time to the cup until the dump truck crosses the finish line. How many paper clips did you put in the cup? __________	Make sure that the truck is in the starting spot on **Road A.** Add the two fishing weights to the back of the dump truck. Add paper clips one at a time to the cup until the dump truck crosses the finish line. How many paper clips did you put in the cup? __________
Empty the cup and put the truck back in the starting spot.	**Empty the cup and move the truck to the starting spot on Road B.**

2. In **Trial 1**, why did the dump truck move when you put the paper clips in the cup? Explain why.

____

____

____

3. Did you notice any difference in the number of paper clips needed to move the truck in **Trials 1** and **2**? What was the difference, if any, and how could you explain it.

____

____

GO TO NEXT PAGE

Task page 9

Directions:

Look at the picture below. Set up your materials for **Trial 3** and **Trial 4** on **Road B** in the same way.

GO TO NEXT PAGE

Task page 10

4.

Trial 3	Trial 4
Make sure your box is at the edge of the table. Put the truck in the starting spot on **Road B**. Put the string through the slot with the cup hanging over the edge of the table. Carefully add paper clips one at a time to the cup until the dump truck crosses the finish line. How many paper clips did you put in the cup? ____________	Make sure that the truck is in the starting spot on **Road B**. Add the two fishing weights to the back of the dump truck. Add paper clips one at a time to the cup until the dump truck crosses the finish line. How many paper clips did you put in the cup? ____________
Empty the cup and put the truck behind the start line.	**Unhook the truck from the string and cup. Remove the cup from Road B.**

5. Why did you need more paper clips to move the truck in **Trial 3** than in **Trial 1**? Explain why.

____

____

____

6. Did you notice any difference in the number of paper clips needed to move the truck in **Trials 4** and **2**? What was the difference, if any, and how could you explain it.

GO TO NEXT PAGE

Task page 11

7. Suppose there was a fifth trial. You put 4 fishing weights into the back of the truck on **Road A**. Would it take more, less, or the same number of paper clips as **Trial 2**?

__________ More   __________ Less   __________ Same

Explain why. ____

8. Based on your results, which road would you take?

__________ Road A or __________ Road B

Explain why. ____

9. Would your choice of roads be affected by how much soil and rocks you have to carry in the back of the truck?

__________ Yes or __________ No

Explain why. ____

10. What would happen on both roads if it had been raining for a day or two? Explain.

GO TO NEXT PAGE

Task page 12

TASK 3 – "Critter Museum"

As the director of the new science museum you have decided to set up a display of animals without backbones that are found in the area. To organize your display you need to sort and classify your collection of animals and provide some information about how they have adapted to the area.

Directions:

- Open **Bag A** and spread the animals on the table.
- Use your hand lens to carefully observe each animal.
- Sort your animals into groups. You must put every animal into a group. Do not make more than 7 groups.

1. Use the following chart to list your groups and tell why you sorted your animals into these groups.

Groups	Letters of Animals in this Group	Reasons

GO TO NEXT PAGE

Task page 13

Directions:

- **Bag B** contains an animal that was found close to your new nature area.
- Open **Bag B**.
- Take out the new animal and compare it to the other animals on the table.

2. Does this new animal fit into one of your groups? ____________

   If yes, which group? Group ____________

   Explain why. ____________

   ____

   ____

3. If the new animal **does not** fit into any of your groups, explain why.

   ____

   ____

   ____

4. What 2 groups are most different from each other?

   Group ____ and Group ____
   Explain how these 2 groups are different from each other.

   ____

   ____

   ____

5. Are these 2 groups similar in any way? ______ Yes ______ No

   Explain why. ____________

   ____

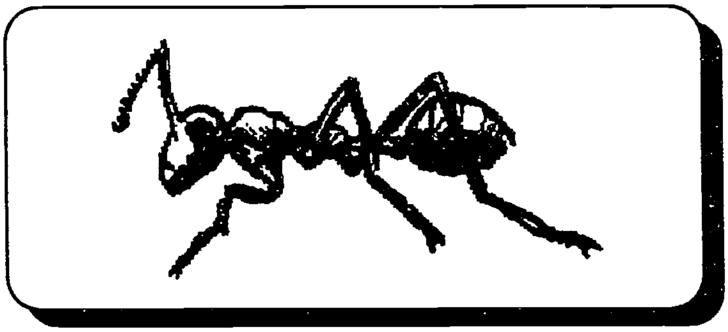
GO ON TO NEXT PAGE

Task page 14

Directions:

- Find the animal that matches the animal shown in the picture below.
- Observe the animal.
- Fill out the information card below on this animal.

Information Card



- The number of this animal is ______
- List 3 characteristics of this animal.

____

____

____

- List 5 ways that this animal might protect itself from other animals and insects:

____

____

____

____

____

Put animals 1 to 10 into Bag A.

Put animal 11 into Bag B.
STOP

SCIENCE

Summer Scoring

Grade 5/6

Los Angeles, July 13–18, 1993

California Learning Assessment System

Performance - Component **Grade 5/6**
TASK -1 - BUILDING

MATERIALS

Big Idea E-3: Geological, geomorphic processes explain the evolution of the Earth.
Exemplar: The Earth undergoes various change processes which have caused its features to change over time. These processes have caused different types of rocks and minerals to form. Wind, water, and ice have changed the Earth's surface over time by wearing down or building up identifiable land forms.

Big Idea E-10: Weather affects living and non-living things.
Exemplar: Weather is unpredictable, varied, and affects daily life. Weather plays a role in the cycles of living and non-living things.

Item Number	Component Rubric
1. Observations of Rocks	4 = Provides (3) indepth and valid descriptions of the properties of each rock with good attention to details. 3 = Provides (2) adequate and valid descriptions of the properties of each rock with attention to detail; or Provides (3) adequate and valid descriptions of the properties of (2) rocks with attention to detail; 2 = Provides (1) partially adequate description with some attention to detail of the properties of each rock; or Provides (2) partially adequate descriptions with some attention to detail of the properties of (2) rocks; or Provides (3) partially adequate descriptions with some attention to details of the properties of (1) rock, other rocks may be blank. 1 = Provides (1) vague or inadequate description with no attention to detail of the properties of each rock; or Provides vague or inadequate descriptions with no attention to detail of the properties of (1) or (2) rocks. 0 = Rewrites question and directions. Response is off-topic. No response, or inappropriate writing or drawing.

2. Explain why	4 = Names a rock. Indepth response clearly based on student's observations. Scientifically appropriate and valid rationale describing why this rock would be best for building tables and benches. 3 = Names a rock. Adequate response mostly based on student's observations. Scientific rationale describing why this rock would be good for building tables and benches. 2 = Names a rock. Partially adequate response which may be based on student's observations. May attempt to contain scientific reasoning, misconceptions are obvious. May attempt to describe why rock would be O.K. for building the tables and benches; or Does not name a rock. Partially adequate response based on student's observations. Attempts to contain scientific reasoning and describes why rock would be O.K. for building the tables and benches. 1 = Does not name a rock. 0 = Rewrites question and directions. Response is off-topic. No response, or inappropriate writing or drawing.
3. Describe and Explain <u>Describe</u> - used nail to scratch the rock. <u>List</u> -nail, penny, etc.	4 = Describes all tools used on each of the 3 rocks. May include additional tests such as 'rock scratches rock', or 'finger nail to scratch rock', etc. Indepth description of what happened to all 3 rocks for each tool used. 3 = Describes most tools used on each of the 3 rocks. Adequate description of what happened to all 3 rocks for each tool used. 2 = May list tools used each of the 3 rocks. Partially adequate description of what happened to all 3 rocks; or May attempt to describe tools used on 2 rocks. Partially adequate description of what happened to same 2 rocks. 1 = May list tools for 1 or 2 rocks. Vague or missing description of what happened to these rocks, or may list tools without providing description of what happened; or May describe tools for 1 rock and provide description of what happened for the 1 rock. 0 = Rewrites question and directions. Response is off-topic. No response, or inappropriate writing or drawing.

4. Other things, reasons and explain Appropriate: Rock scratch rock Fingernail Vinegar/Acid Rain Weight Etc.... Inappropriate:	4 = Lists at least 3-4 other tests/things that are appropriate and valid. Appropriate and valid rationales/explanations for each test describing why this test would be conducted. 3 = Lists 2-3 other tests/things that are appropriate and valid. Mostly adequate rationales/explanations for each test describing why this test would be conducted. 2 = Lists 1-2 other tests/things that are partially appropriate and some may be valid. Partially adequate rationales/explanations for each test which may describe why this test would be conducted; or Lists 3-4 other tests/things that are partially appropriate and may be valid. No rationales/explanations. 1 = May attempt to list some other tests/things that are inappropriate. May attempt to include vague/inappropriate rationale/explanation. May list some inappropriate tests/things and no rationale/explanation. 0 = Rewrites question and directions. Response is off-topic. No response, or inappropriate writing or drawing.
5. Relationship between data and conclusions	4 = Names a rock. Rationale demonstrates indepth understanding of weathering, erosion, and the effects of weather on the surface of the earth. Clearly and effectively shows relationship between data and conclusions. Explanation clearly describes why this rock would be best for building tables and benches. Hardness of rock/last longest. 3 = Names a rock. Rationale demonstrates adequate understanding of weathering, erosion, and the effects of weather on the surface of the earth. Shows relationship between data and conclusions. Explanation describes why this rock would be good for building tables and benches. 2 = Names a rock. (May not name a rock) Rationale demonstrates partially adequate understanding of weathering, erosion, and the effects of weather on the surface of the earth. Many misconceptions are evident. Some attempt may be made to show relationship between data and conclusions. Explanation may attempt to describe why this rock would be O.K. for building tables and benches, but is vague and flawed. 1 = Does not name a rock. If a rationale is present, there is very limited understanding of weathering, erosion, and the effects of weather on the surface of the earth. Many misconceptions are evident. No attempt to show the relationship between data and conclusions. No attempt to describe why this rock would be O.K. for building tables and benches. 0 = Rewrites question and directions. Response is off-topic. No response, or inappropriate writing or drawing.

6. Explain and apply	4 = Explanation clearly and effectively demonstrates indepth understanding of how the effects of weather (rain, wind, ice, snow, etc.) have changed the surface of the earth over time, and how this might effect the benches and tables because they are made of rocks. May also include discussion regarding weathering, erosion, acid rain and pollution, and properties of rocks. (Water get into cracks, freeze, break rocks apart; Wind act as sand paper and wear down; etc.) 3 = Names a rock. Rationale demonstrates adequate understanding of weathering, erosion, and the effects of weather on the surface of the earth. Shows relationship between data and conclusions. Explanation describes why this rock would be good for building tables and benches. 2 = Names a rock. (May not name a rock) Rationale demonstrates partially adequate understanding of weathering, erosion, and the effects of weather on the surface of the earth. Many misconceptions are evident. Some attempt may be made to show relationship between data and conclusions. Explanation may attempt to describe why this rock would be O.K. for building tables and benches, but is vague and flawed. 1 = Does not name a rock. If a rationale is present, there is very limited understanding of weathering, erosion, and the effects of weather on the surface of the earth. Many misconceptions are evident. No attempt to show the relationship between data and conclusions. No attempt to describe why this rock would be O.K. for building tables and benches. 0 = Rewrites question and directions. Response is off-topic. No response, or inappropriate writing or drawing.

Performance - Component

Grade 5/6
TASK -2 - Which Road is Best?

Big Idea P-8: Forces cause change in motion.
Exemplar: Matter stays at rest until a force such as a push or pull is applied. The amount of movement of matter is dependent upon the amount of force exerted. Forces such as gravity and friction, move things in measurable ways.

Big Idea P-9: Energy can produce work.
Exemplar: Energy can be used to do mechanical work.

Item Number	**Component Rubric**
1. Number of washers for Road	3 = Writes appropriate approximation of washers for both trials: Trial 1 empty truck at starting point ______washers Trial 2 weights in back of truck at starting point _____washers 2 = Writes appropriate approximation of washers for one trial and inappropriate approximation for the other trial: Trial 1 empty truck at starting point ______washers Trial 2 weights in back of truck at starting point _____washers 1 = Writes inappropriate approximation of washers for both trials: Trial 1 empty truck at starting point ______washers Trial 2 weights in back of truck at starting point _____washers 0 = No response, or inappropriate writing or drawing.

2. Explain why truck moved in Trial 1 on Road A	4 = Response demonstrates indepth understanding of the scientific concepts related to force, motion, and energy.. Matter stays at rest until a force such as a push or pull is applied. The amount of movement of matter is dependent upon the amount of force exerted. Strong rationale for why the truck moved. (The dump truck didn't move when the cup was empty on Road A because.... The truck moved when ____washers were added to the cup because...) 3 = Response demonstrates adequate understanding of the scientific concepts related to force, motion, and energy, but may include some minor misconceptions. Includes a rationale. 2 = Response demonstrates limited understanding of the scientific concepts related to force, motion, and energy, and include many misconceptions. Vague or unclear rationale. 1 = Response demonstrates extremely limited or no understanding of the scientific concepts related to force, motion, and energy, and include major misconceptions. No rationale. 0 = Rewrites question and directions. Response is off-topic. No response, or inappropriate writing or drawing.

3. Explain difference between Trial 1 and Trial 2 on Road A	4 = Answers yes.. Response demonstrates indepth understanding of the scientific concepts related to force, motion, and energy. Response should describe how forces cause change in motion. Matter stays at rest until a force such as a push or pull is applied. The amount of movement of matter is dependent upon the amount of force exerted. Forces such as gravity and friction, move things in measurable ways. States strong rationale for the difference in the number of washers needed to move the truck in Trial 2 than in Trial 1. (Less number of washers needed in Trial 1 than 2 because in Trial 1 the back of the truck was empty, and the truck was lighter. In Trial 2 there was weight in the back of the truck, which made the truck heavier, so it took more energy -washers in the cup to move it.) 3 = Answers yes. Response demonstrates adequate understanding of the scientific concepts related to force, motion, and energy, but may include some minor misconceptions. Includes rationale. 2 = Answer yes. Response demonstrates limited understanding of the scientific concepts related to force, motion, and energy, and include many misconceptions. Vague or unclear rationale. 1 = Answer no Response demonstrates extremely limited or no understanding of the scientific concepts related to force, motion, and energy, and include major misconceptions. No rationale. Answer yes, but no explanation or rationale states. 0 = Rewrites question and directions. Response is off-topic. No response, or inappropriate writing or drawing.
4. Number of washers for Road B	3 = Writes appropriate approximation of washers for both trials: Trial 1 empty truck at starting point _______washers Trial 2 weights in back of truck at starting point _____washers 2 = Writes appropriate approximation of washers for one trial and inappropriate approximation for the other trial: Trial 1 empty truck at starting point _______washers Trial 2 weights in back of truck at starting point _____washers 1 = Writes inappropriate approximation of washers for both trials: Trial 1 empty truck at starting point _______washers Trial 2 weights in back of truck at starting point _____washers 0 = No response, or inappropriate writing or drawing.

5. Explain difference between Trial 3 - Road B and Trial 1 - Road A	4 = Response demonstrates indepth understanding of the scientific concepts related to force, motion, and energy.. Response should describe how forces cause change in motion. Matter stays at rest until a force such as a push or pull is applied. The amount of movement of matter is dependent upon the amount of force exerted. Forces such as gravity and friction, move things in measurable ways. States strong rationale for using more washers to move the truck in Trial 3 (Road B) than in Trial 1 (Road A). 3 = Response demonstrates adequate understanding of the scientific concepts related to force, motion, and energy, but may include some minor misconceptions. Includes rationale for using more washers to move the truck in Trial 3 (Road B) than in Trial 1 (Road A). 2 = Response demonstrates limited understanding of the scientific concepts related to force, motion, and energy, and includes many misconceptions. Vague or unclear rationale why it took more washers to move the truck in Trial 3 (Road B) than in Trial 1 (Road A). 1 = Response demonstrates extremely limited or no understanding of the scientific concepts related to force, motion, and energy, and include major misconceptions. No rationale. 0 = Rewrites question and directions. Response is off-topic. No response, or inappropriate writing or drawing.

6. Explain difference between Trial 4 - Road B and Trial 2 - Road A	4 = Answers yes Response demonstrates indepth understanding of the scientific concepts related to force, motion, and energy.. Response should describe how forces cause change in motion. Matter stays at rest until a force such as a push or pull is applied. The amount of movement of matter is dependent upon the amount of force exerted. Forces such as gravity and friction, move things in measurable ways. States strong rationale for using more washers to move the truck in Trial 4 (Road B) than in Trial 2 (Road A). 3 = Answers yes Response demonstrates adequate understanding of the scientific concepts related to force, motion, and energy, but may include some minor misconceptions. Includes rationale for using more washers to move the truck in Trial 4 (Road B) than in Trial 2 (Road A). 2 = Answer yes Response demonstrates limited understanding of the scientific concepts related to force, motion, and energy, and includes many misconceptions. Vague or unclear rationale why it took more washers to move the truck in Trial 4 (Road B) than in Trial 2 (Road A).. 1 = Answer no Response demonstrates extremely limited or no understanding of the scientific concepts related to force, motion, and energy, and include major misconceptions. No rationale. Answer yes, but no explanation or rationale states. 0 = Rewrites question and directions. Response is off-topic. No response, or inappropriate writing or drawing.

7. Predict and Explain What if Trial 5? Trial 5- Road A and Trial 2 - Road A	4 = Answers more, predict results without conducting trial Response demonstrates indepth understanding of the scientific concepts related to force, motion, and energy. Response should describe how forces cause change in motion. Matter stays at rest until a force such as a push or pull is applied. The amount of movement of matter is dependent upon the amount of force exerted. Forces such as gravity and friction, move things in measurable ways. States strong rationale for using more washers to move the truck in Trial 5 (Road A) than in Trial 2 (Road A). 3 = Answers more, predict results without conducting trial. Response demonstrates adequate understanding of the scientific concepts related to force, motion, and energy, but may include some minor misconceptions. Includes rationale for using more washers to move the truck in Trial 5 (Road A) than in Trial 2 (Road A). 2 = Answer same or maybe more, attempts to predict. Response demonstrates limited understanding of the scientific concepts related to force, motion, and energy, and includes many misconceptions. Vague or unclear rationale why it took more washers to move the truck in Trial 5 (Road A) than in Trial 2 (Road A).. 1 = Answer fewer, or maybe same, little or no attempt to predict. Response demonstrates extremely limited or no understanding of the scientific concepts related to force, motion, and energy, and include major misconceptions. No rationale. Answer more, fewer, or same, but no explanation or rationale stated. 0 = Rewrites question and directions. Response is off-topic. No response, or inappropriate writing or drawing.

8. Apply, Draw conclusions based on results	4 = Answers Road A Response demonstrates indepth understanding of the scientific concepts related to force, motion, and energy.. Response should describe how forces cause change in motion. Matter stays at rest until a force such as a push or pull is applied. The amount of movement of matter is dependent upon the amount of force exerted. Forces such as gravity and friction, move things in measurable ways. States strong rationale for why Road A would be better to remove soil and rocks clearly based on own results. 3 = Answers Road A Response demonstrates adequate understanding of the scientific concepts related to force, motion, and energy, but may include some minor misconceptions. Includes rationale for why Road A would be better to remove the soil and rocks mostly based on own results. 2 = Answer Road A Response demonstrates limited understanding of the scientific concepts related to force, motion, and energy, and includes many misconceptions. Vague or unclear rationale why Road A would be better than Road B. Inadequate or no attempt to base answer on own results. 1 = Answer Road B Response demonstrates extremely limited or no understanding of the scientific concepts related to force, motion, and energy, and include major misconceptions. No rationale and no attempt to use results. Answer Road A or B, but no explanation or rationale stated. 0 = Rewrites question and directions. Response is off-topic. No response, or inappropriate writing or drawing.

9. Apply, use results to draw conclusions	4 = Answers yes Response demonstrates indepth understanding of the scientific concepts related to force, motion, and energy. Response should describe how forces cause change in motion. Matter stays at rest until a force such as a push or pull is applied. The amount of movement of matter is dependent upon the amount of force exerted. Forces such as gravity and friction, move things in measurable ways. States strong rationale for why choice of roads would be affected by amount of rocks and soil and the decision would be clearly based on own results. Shows relationship between amount of weight in back of truck and type of road. 3 = Answers yes Response demonstrates adequate understanding of the scientific concepts related to force, motion, and energy, but may include some minor misconceptions. Includes rationale for why choice of roads would be affected by amount of rocks and soil and the decision would be mostly based on own results. Attempts to show relationship between amount of weight in back of truck and type of road. 2 = Answer yes Response demonstrates limited understanding of the scientific concepts related to force, motion, and energy, and includes many misconceptions. Vague or unclear rationale why choice of roads would be affected by amount of rocks and soil and the decision may or may not be based on own results. In adequate or no attempts to show relationship between amount of weight in back of truck and type of road. 1 = Answer no Response demonstrates extremely limited or no understanding of the scientific concepts related to force, motion, and energy, and include major misconceptions. No rationale and no attempt to use own results. No attempt to show relationship between amount of weight in the back of the truck and the type of road. Answer yes or no, but no explanation or rationale stated. 0 = Rewrites question and directions. Response is off-topic. No response, or inappropriate writing or drawing.

10. Inference and application	4 = In-depth description of what would happen on both Road A and Road B on rainy days with strong rationale for both. Response demonstrates indepth understanding of the scientific concepts related to force, motion, and energy. Clearly and effectively uses results from own trials to support conclusions. 3 = Adequate description of what would happen on both Road A and Road B on rainy days with a rationale for both. Response demonstrates adequate understanding of the scientific concepts related to force, motion, and energy. Minor misconceptions. Uses some results from own trials to support conclusions. 2 = Limited description of what would happen on either Roar A or Road B on rainy days with a very limited rationale for both roads. Response demonstrates very limited understanding of the scientific concepts related to force, motion, and energy. Many misconceptions. May attempt to use results from own trials to support conclusions. 1 = Extremely limited or no attempt to describe what would happen on either Road A or B on a rainy day. Response demonstrates limited or no understanding of the scientific concepts related to force, motion, and energy, and include major misconceptions. No rationale. No attempt to use results from own trials to support conclusions, if conclusions are attempted. 0 = Rewrites question and directions. Response is off-topic. No response, or inappropriate writing or drawing.

Performance - Component Museum

Grade 5/6
TASK -3 - Critter

Big Idea L-10: Living things are diverse.
Exemplar: Although all living things have common characteristics, there are many different kinds of living things that can be sorted into groups..

Big Idea L-11: Organisms are classified by shared derived characteristics.
Exemplar: We group organisms by some of their similar characteristics.

Big Idea L-12: All living things interact with each other and their physical environment through distinct roles.
Exemplar: Living things do not live alone; they are always interacting with each other, like when they eat prey or are eaten by a predator. Organisms are always interacting with the physical environment, like when they make shelter.

Item Number	Component Rubric
1. Grouping animals and explaining why they are grouped together in a particular group Attributes: -insects -invertebrates -arachnids -wings/no wings -flies vs crawls -color/size -antenna shape/length -spiders vs not -harmful/not -rough legs/smooth -feeds on seeds/ plants vs other animals -camouflaged/not -poisonous/not -number of legs -eyes/eye stem	4 = All 12 animals from Bag A are sorted into groups of at least 2, but no more than 7. Each group has a letter and the identification number for each animal is written in the group. Uses complex attributes beyond color and size. All sortings are clearly stated with clear descriptions that match the animals. Provides detailed and specific comparisons with a strong and clearly stated rationale for each group. Clearly describes how all of the animals in each group are similar. May include pictures in addition to written rationale. (All 12 animals accounted for.) 3 = Most animals from Bag A are sorted into groups of at least 2, but no more than 7. Most groups have a letter, and the identification number for each animal is written in the group. Uses basic attributes for the sortings. Most sortings contain descriptions that match the animals. Provides comparisons with rationale for each group. Describes how most of the animals in most groups are similar. May include some pictures in addition to written rationale. (At least 8 animals accounted for.) 2 = Many animals from Bag A are sorted into groups. May contain more than 7 groups, with many 1 animal groupings. Some groups have a letter and some of the identification numbers for some of the animals are written in the group. Uses simple or limited attributes to group the animals, and not all animals are accounted for. (At least 4-6 animals are accounted for.). Sortings are not clearly stated and descriptions do not always match the animals. Rationale is vague, unclear, or missing.. 1 = Attempts to sort some animals from Bag A into groups. Maybe 1 group has a letter, and the rest are not lettered. The identification numbers for a few animals may be recorded in the groups, but most are not recorded. Accounts for at least 2-4 animals. No rationale, or if a rationale is present , it is extremely vague, or doesn't match animal(s). 0 = No response, or attempt to sort/classify animals. Rewrites directions. Inappropriate writing or drawing. Writes off-topic.

2. Bag B Animal Does it fit into any of the groups?	4 = Answers yes or no and identifies an appropriate group in which the new animal will fit. Provides in-depth explanation of why/how this new animal either fits or why/how it doesn't fit. 3 = Answers yes or no and identifies a group in which the animal would fit, which might not be completely appropriate. Provides an explanation of why/how this new animal either fits, or why/how it doesn't fit. Rationale may contain some minor misconceptions, or may not be completely accurate/appropriate. 2 = Answers yes or no but Vague or unclear rationale. 1 = Response demonstrates extremely limited or no understanding of the scientific concepts related to force, motion, and energy, and include major misconceptions. No rationale. 0 = Rewrites question and directions. Response is off-topic. No response, or inappropriate writing or drawing.

3. Explain difference between Trial 1 and Trial 2 on Road A	4 = Answers yes.. Response demonstrates indepth understanding of the scientific concepts related to force, motion, and energy.. Response should describe how forces cause change in motion. Matter stays at rest until a force such as a push or pull is applied. The amount of movement of matter is dependent upon the amount of force exerted. Forces such as gravity and friction, move things in measurable ways. States strong rationale for the difference in the number of washers needed to move the truck in Trial 2 than in Trial 1. (Less number of washers needed in Trial 1 than 2 because in Trial 1 the back of the truck was empty, and the truck was lighter.. In Trial 2 there was weight in the back of the truck, which made the truck heavier, so it took more energy -washers in the cup to move it.) 3 = Answers yes. Response demonstrates adequate understanding of the scientific concepts related to force, motion, and energy, but may include some minor misconceptions. Includes rationale. 2 = Answer yes. Response demonstrates limited understanding of the scientific concepts related to force, motion, and energy, and include many misconceptions. Vague or unclear rationale. 1 = Answer no Response demonstrates extremely limited or no understanding of the scientific concepts related to force, motion, and energy, and include major misconceptions. No rationale. Answer yes, but no explanation or rationale states. 0 = Rewrites question and directions. Response is off-topic. No response, or inappropriate writing or drawing.
4. Number of washers for Road B	3 = Writes appropriate approximation of washers for both trials: Trial 1 empty truck at starting point _______washers Trial 2 weights in back of truck at starting point _____washers 2 = Writes appropriate approximation of washers for one trial and inappropriate approximation for the other trial: Trial 1 empty truck at starting point _______washers Trial 2 weights in back of truck at starting point _____washers 1 = Writes inappropriate approximation of washers for both trials: Trial 1 empty truck at starting point _______washers Trial 2 weights in back of truck at starting point _____washers 0 = No response, or inappropriate writing or drawing.

5. Explain difference between Trial 3 - Road B and Trial 1 - Road A	4 = Response demonstrates indepth understanding of the scientific concepts related to force, motion, and energy. Response should describe how forces cause change in motion. Matter stays at rest until a force such as a push or pull is applied. The amount of movement of matter is dependent upon the amount of force exerted. Forces such as gravity and friction, move things in measurable ways. States strong rationale for using more washers to move the truck in Trial 3 (Road B) than in Trial 1 (Road A). 3 = Response demonstrates adequate understanding of the scientific concepts related to force, motion, and energy, but may include some minor misconceptions. Includes rationale for using more washers to move the truck in Trial 3 (Road B) than in Trial 1 (Road A). 2 = Response demonstrates limited understanding of the scientific concepts related to force, motion, and energy, and includes many misconceptions. Vague or unclear rationale why it took more washers to move the truck in Trial 3 (Road B) than in Trial 1 (Road A). 1 = Response demonstrates extremely limited or no understanding of the scientific concepts related to force, motion, and energy, and include major misconceptions. No rationale. 0 = Rewrites question and directions. Response is off-topic. No response, or inappropriate writing or drawing.

6. Explain difference between Trial 4 - Road B and Trial 2 - Road A	4 = Answers yes Response demonstrates indepth understanding of the scientific concepts related to force, motion, and energy.. Response should describe how forces cause change in motion. Matter stays at rest until a force such as a push or pull is applied. The amount of movement of matter is dependent upon the amount of force exerted. Forces such as gravity and friction, move things in measurable ways. States strong rationale for using more washers to move the truck in Trial 4 (Road B) than in Trial 2 (Road A). 3 = Answers yes Response demonstrates adequate understanding of the scientific concepts related to force, motion, and energy, but may include some minor misconceptions. Includes rationale for using more washers to move the truck in Trial 4 (Road B) than in Trial 2 (Road A). 2 = Answer yes Response demonstrates limited understanding of the scientific concepts related to force, motion, and energy, and includes many misconceptions. Vague or unclear rationale why it took more washers to move the truck in Trial 4 (Road B) than in Trial 2 (Road A).. 1 = Answer no Response demonstrates extremely limited or no understanding of the scientific concepts related to force, motion, and energy, and include major misconceptions. No rationale. Answer yes, but no explanation or rationale states. 0 = Rewrites question and directions. Response is off-topic. No response, or inappropriate writing or drawing.

7. Predict and Explain What if Trial 5? Trial 5- Road A and Trial 2 - Road A	4 = Answers more, predict results without conducting trial Response demonstrates indepth understanding of the scientific concepts related to force, motion, and energy.. Response should describe how forces cause change in motion. Matter stays at rest until a force such as a push or pull is applied. The amount of movement of matter is dependent upon the amount of force exerted. Forces such as gravity and friction, move things in measurable ways. States strong rationale for using more washers to move the truck in Trial 5 (Road A) than in Trial 2 (Road A). 3 = Answers more, predict results without conducting trial Response demonstrates adequate understanding of the scientific concepts related to force, motion, and energy, but may include some minor misconceptions. Includes rationale for using more washers to move the truck in Trial 5 (Road A) than in Trial 2 (Road A). 2 = Answer same or maybe more, attempts to predict Response demonstrates limited understanding of the scientific concepts related to force, motion, and energy, and includes many misconceptions. Vague or unclear rationale why it took more washers to move the truck in Trial 5 (Road A) than in Trial 2 (Road A).. 1 = Answer fewer, or maybe same, little or no attempt to predict Response demonstrates extremely limited or no understanding of the scientific concepts related to force, motion, and energy, and include major misconceptions. No rationale. Answer more, fewer, or same, but no explanation or rationale stated. 0 = Rewrites question and directions. Response is off-topic. No response, or inappropriate writing or drawing.

8. Apply, Draw conclusions based on results	4 = Answers Road A Response demonstrates indepth understanding of the scientific concepts related to force, motion, and energy.. Response should describe how forces cause change in motion. Matter stays at rest until a force such as a push or pull is applied. The amount of movement of matter is dependent upon the amount of force exerted. Forces such as gravity and friction, move things in measurable ways. States strong rationale for why Road A would be better to remove soil and rocks clearly based on own results. 3 = Answers Road A Response demonstrates adequate understanding of the scientific concepts related to force, motion, and energy, but may include some minor misconceptions. Includes rationale for why Road A would be better to remove the soil and rocks mostly based on own results. 2 = Answer Road A Response demonstrates limited understanding of the scientific concepts related to force, motion, and energy, and includes many misconceptions. Vague or unclear rationale why Road A would be better than Road B. Inadequate or no attempt to base answer on own results. 1 = Answer Road B Response demonstrates extremely limited or no understanding of the scientific concepts related to force, motion, and energy, and include major misconceptions. No rationale and no attempt to use results. Answer Road A or B, but no explanation or rationale stated. 0 = Rewrites question and directions. Response is off-topic. No response, or inappropriate writing or drawing.

9. Apply, use results to draw conclusions	4 = Answers yes Response demonstrates indepth understanding of the scientific concepts related to force, motion, and energy.. Response should describe how forces cause change in motion. Matter stays at rest until a force such as a push or pull is applied. The amount of movement of matter is dependent upon the amount of force exerted. Forces such as gravity and friction, move things in measurable ways. States strong rationale for why choice of roads would be affected by amount of rocks and soil and the decision would be clearly based on own results. Shows relationship between amount of weight in back of truck and type of road. 3 = Answers yes Response demonstrates adequate understanding of the scientific concepts related to force, motion, and energy, but may include some minor misconceptions. Includes rationale for why choice of roads would be affected by amount of rocks and soil and the decision would be mostly based on own results. Attempts to show relationship between amount of weight in back of truck and type of road. 2 = Answer yes Response demonstrates limited understanding of the scientific concepts related to force, motion, and energy, and includes many misconceptions. Vague or unclear rationale why choice of roads would be affected by amount of rocks and soil and the decision may or may not be based on own results. In adequate or no attempts to show relationship between amount of weight in back of truck and type of road. 1 = Answer no Response demonstrates extremely limited or no understanding of the scientific concepts related to force, motion, and energy, and include major misconceptions. No rationale and no attempt to use own results. No attempt to show relationship between amount of weight in the back of the truck and the type of road. Answer yes or no, but no explanation or rationale stated. 0 = Rewrites question and directions. Response is off-topic. No response, or inappropriate writing or drawing.

10. Inference and application	4 = In-depth description of what would happen on both Road A and Road B on rainy days with strong rationale for both. Response demonstrates indepth understanding of the scientific concepts related to force, motion, and energy. Clearly and effectively uses results from own trials to support conclusions. 3 = Adequate description of what would happen on both Road A and Road B on rainy days with a rationale for both. Response demonstrates adequate understanding of the scientific concepts related to force, motion, and energy. Minor misconceptions. Uses some results from own trials to support conclusions. 2 = Limited description of what would happen on either Roar A or Road B on rainy days with a very limited rationale for both roads. Response demonstrates very limited understanding of the scientific concepts related to force, motion, and energy. Many misconceptions. May attempt to use results from own trials to support conclusions. 1 = Extremely limited or no attempt to describe what would happen on either Road A or B on a rainy day. Response demonstrates limited or no understanding of the scientific concepts related to force, motion, and energy, and include major misconceptions. No rationale. No attempt to use results from own trials to support conclusions, if conclusions are attempted. 0 = Rewrites question and directions. Response is off-topic. No response, or inappropriate writing or drawing.

13. CLAS—Grade 10

This activity was developed by the California Learning Assessment System (CLAS), and it was administered to students in grade 9 in 1994. The activity coordinates three performance tasks, *Decline in Freshwater Animal Populations* (life science), *Hot Rocks and Water* (physical science), and *Rock Erosion* (earth science), through the story line, *The Captain and Lake Wilmar*. Students take all three tasks in order. For *Decline in Freshwater Animal Populations*, students use pH paper and water samples to investigate the effects of pH on freshwater animals. In *Hot Rocks and Water*, students use limestone samples and hot water baths to investigate the concepts of heat and temperature. For *Rock Erosion*, students investigate the effects of polluted versus nonpolluted water on rocks.

The components of the CLAS—GRADE 10 task will be found on the following pages:

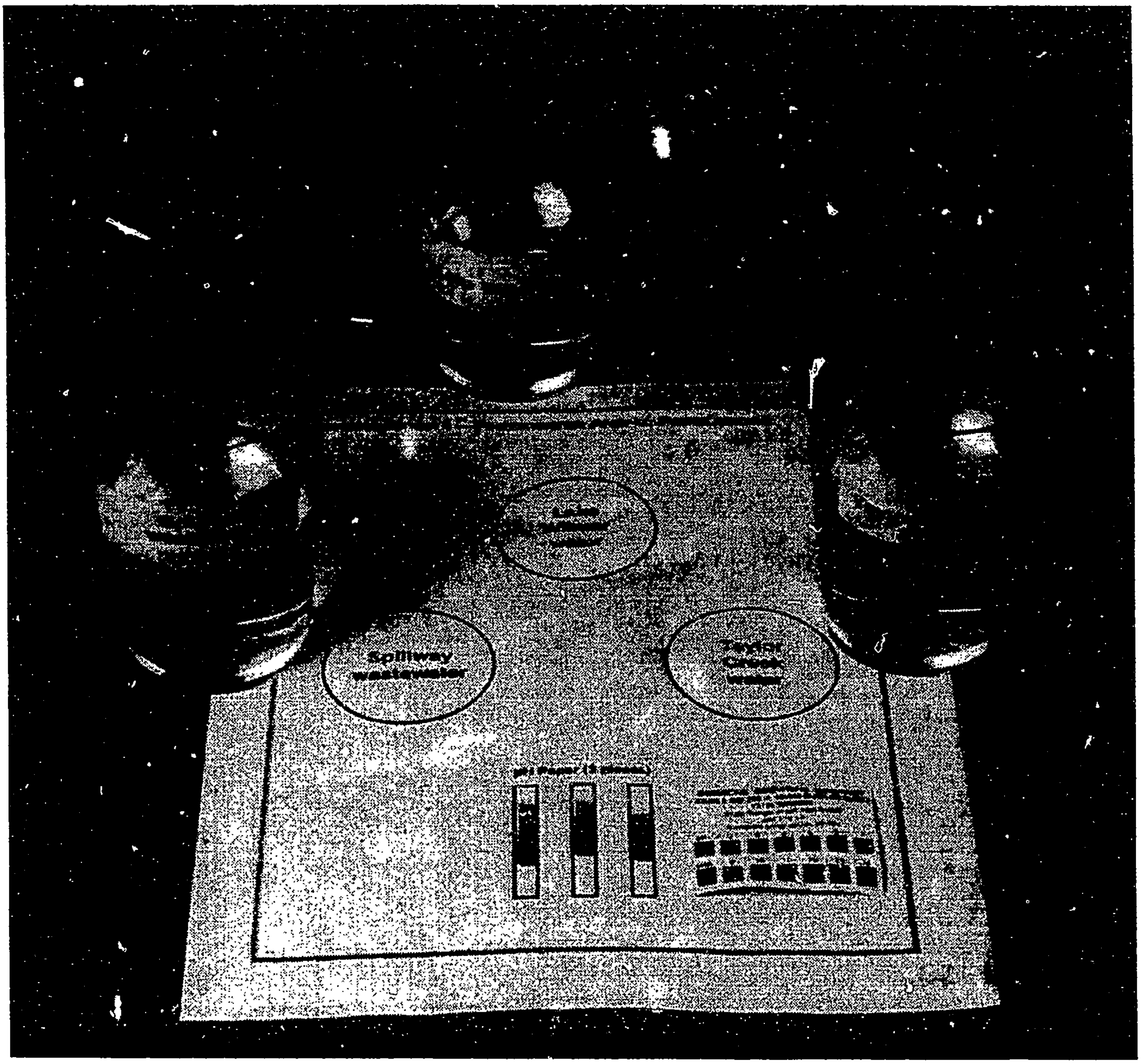


Figure 17—Equipment for CLAS Grade 10—Animals

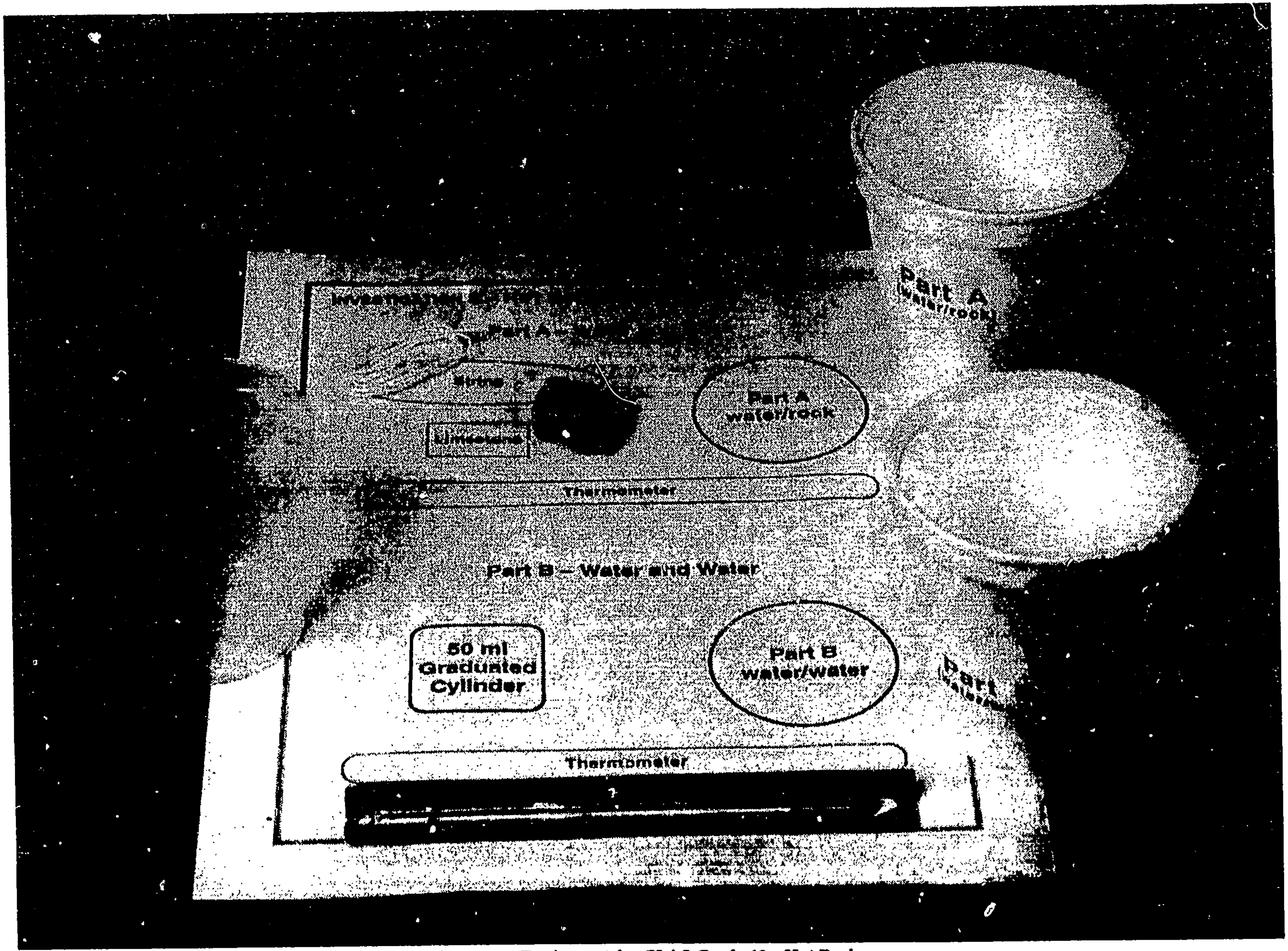


Figure 18—Equipment for CLAS Grade 10—Hot Rocks

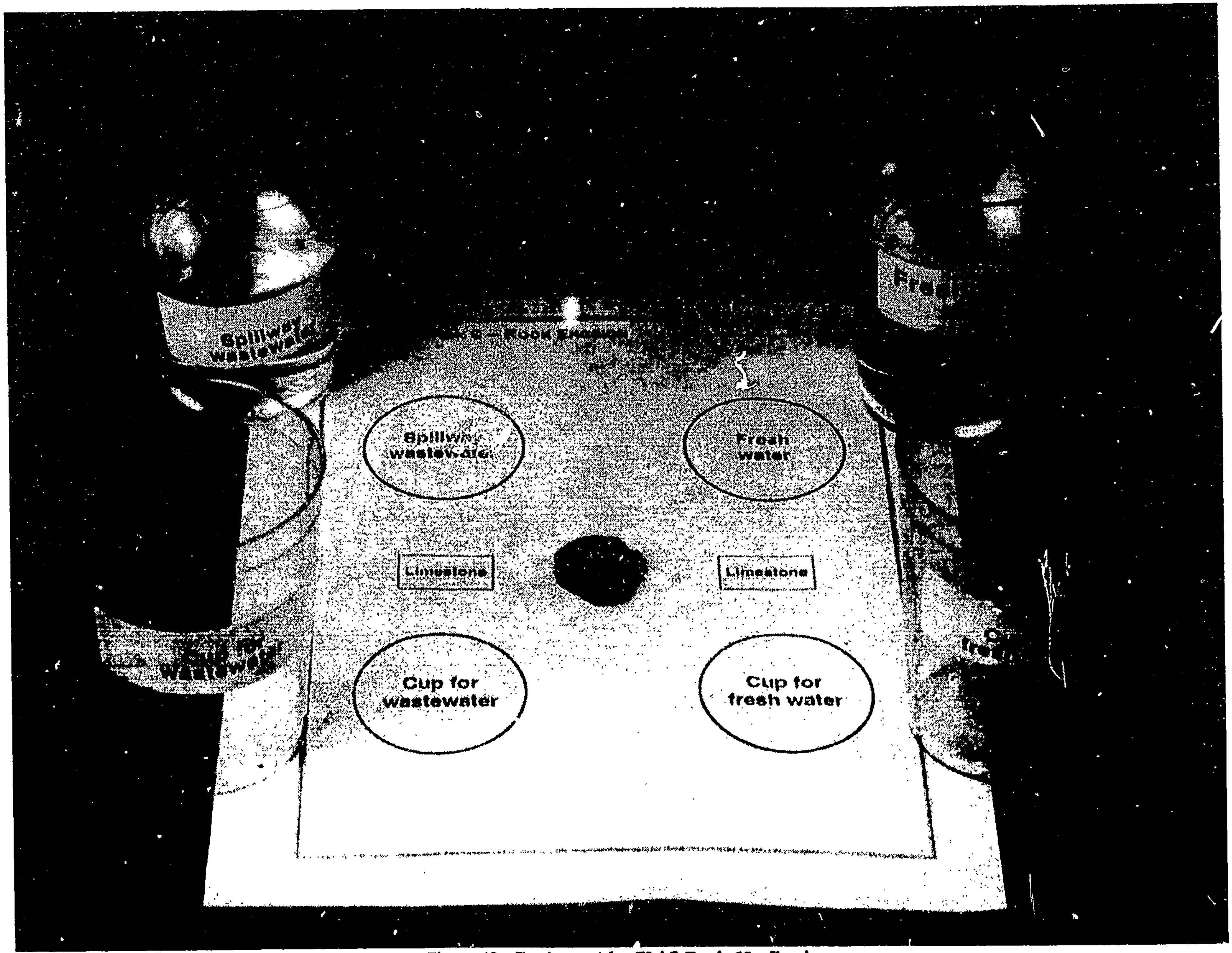


Figure 19—Equipment for CLAS Grade 10—Erosion

Task page 1 Student ID Number ______

CALIFORNIA LEARNING ASSESSMENT SYSTEM

Spring 1993 Research Pilot
Performance-Based Assessment
Grade 10

Science

Form 1

Student Answer Sheet

Name: ______________________________

Date: ______________ Grade: ______________

Sex: M or F Date of Birth: ______________

Teacher: ______________________________

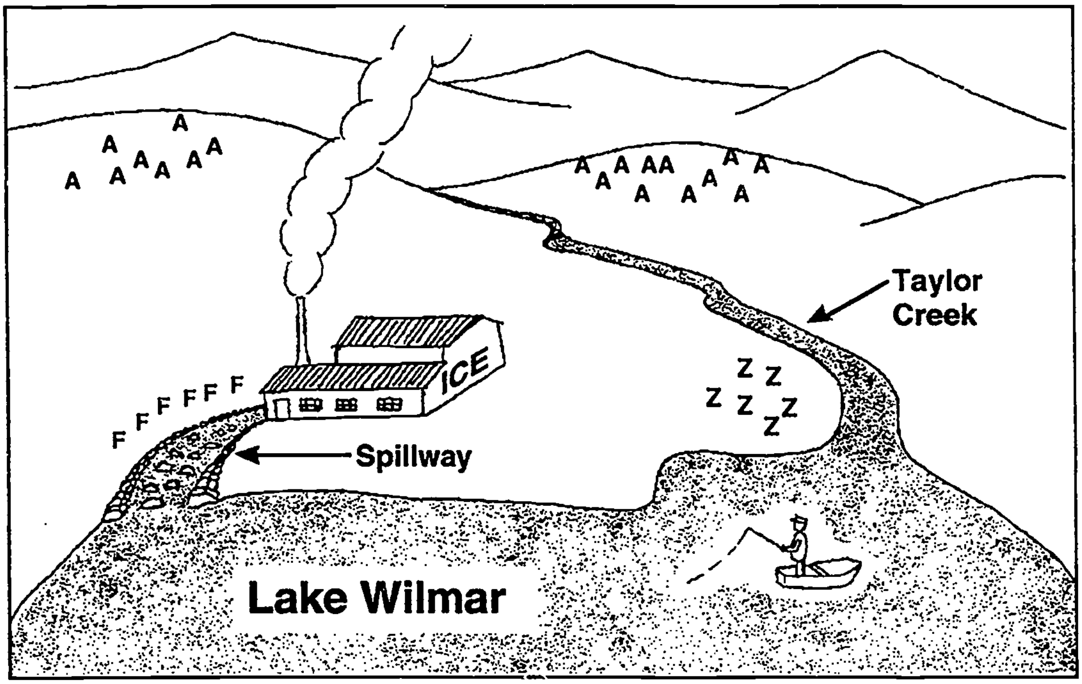
School: ______________________________

Language spoken at home: ______________________________

STOP

Task page 2

The Captain and Lake Wilmar



What's happening in Lake Wilmar?

Old Captain McDermit has been fishing at Lake Wilmar for the past 25 years. Ten years ago, an ice-making plant was built on the shore of the lake. Since then, Captain McDermit has noticed that the population of animals living by and in the lake has been decreasing.

However, Captain McDermit has noticed that in nearby Taylor Creek, the fish population is still abundant. Taylor Creek is a freshwater stream flowing into Lake Wilmar.

The ice-making plant was built at this site for two reasons:

1. The weather was cooler than at an alternate site ten miles away from the lake, on the other side of the mountain.

2. The lake supplied the water needed in ice making.

An effort was made to ensure that the wastewater from the plant did not harm the plants and animals in the lake. A long spillway, made of the native limestone rock, was constructed to add oxygen to the water for the benefit of the wildlife.

GO ON TO THE NEXT PAGE

Task page 3

Directions

You are going to be doing three investigations associated with the ice-making plant and the Lake Wilmar area. They are

Investigation 1 – Decline in Freshwater Animal Populations

Investigation 2 – Hot Rocks and Water

Investigation 3 – Rock Erosion

To complete these investigations, you will need to do the following:

- Take this answer booklet with you as you go to each station.
- Make careful observations.
- Carefully record, organize, and graph your data and observations.
- Analyze your data clearly using your observations for support.
- Clean up the station when you are finished and leave the materials as you found them.

Time is limited. Work quickly and carefully. There is not enough time to repeat the experiments.

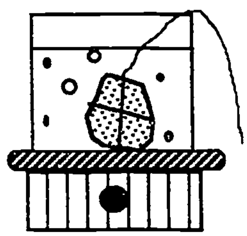
Before going to the first investigation, you need to start the following to save time later.

❑ Use the balance to determine the mass of the rock on your placemat.

Mass of rock: ________

Task page 4

- [ ] Tie a string on the rock and place it in the hot water bath at your station for at least 7 minutes. You will be using both the rock and the hot water in **Investigation 2**.

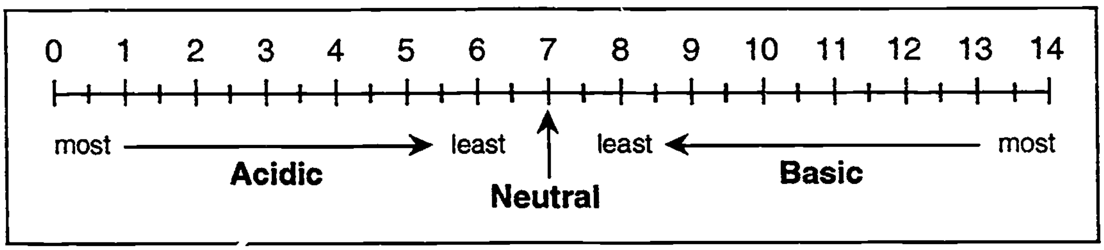


Investigation 1 – Decline in Freshwater Animal Populations

Directions:

Your task is to determine and then compare the pH of samples of water from Lake Wilmar, wastewater from the ice-making plant, and water from Taylor Creek, which flows into the lake. The pH scale measures the strength of an acid or base.

The pH Scale



The following directions can also be found on the placemat.

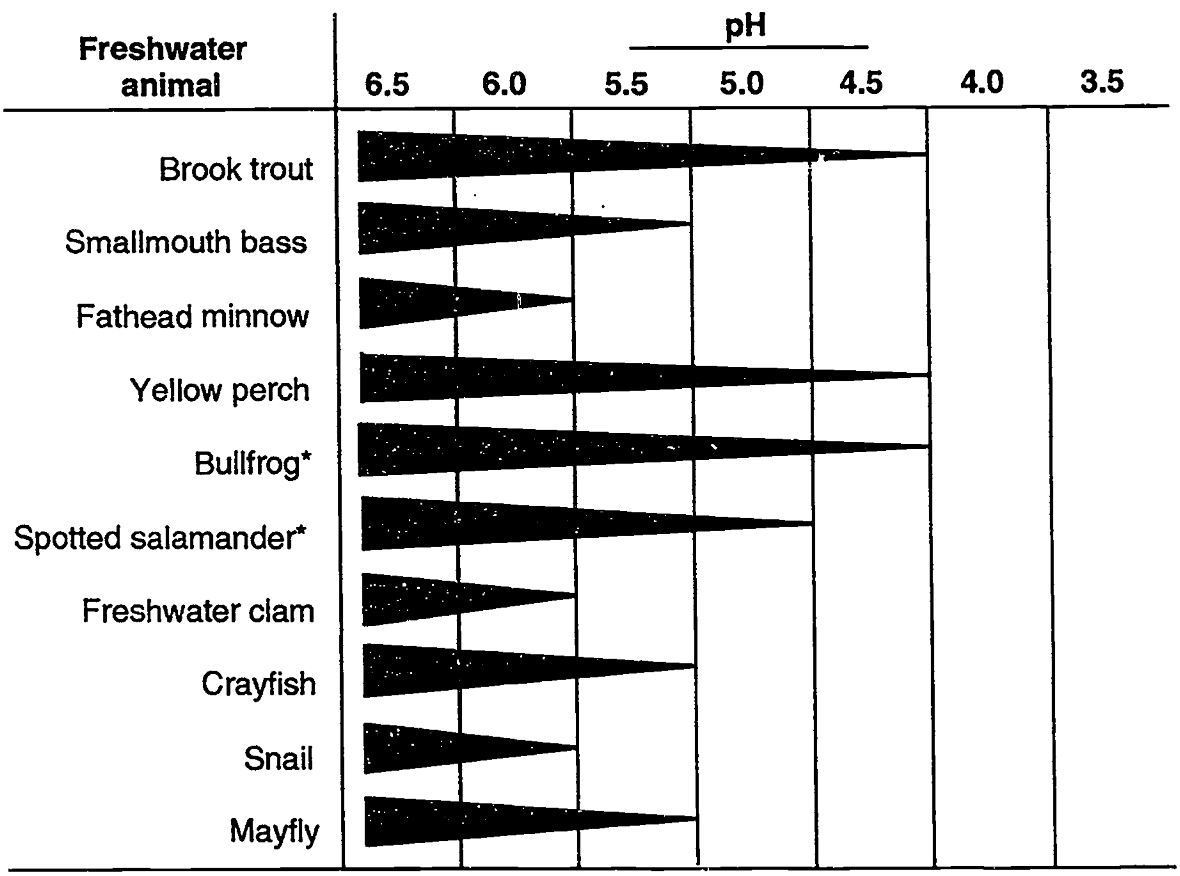
- ☐ Use pH paper to determine the pH of the water from Lake Wilmar.
- ☐ Use pH paper to determine the pH of wastewater from the ice-making plant.
- ☐ Use pH paper to determine the pH of water from Taylor Creek.

1. Briefly record your observations.

Task page 6

The information on the chart below was prepared by a wildlife organization. It records the effect of pH on freshwater animals. The thickness of the line indicates the ability of the species to survive at different pH values. (The thicker the line, the higher the survival rate for that species.)

The Effect of pH on Freshwater Animals



* Embryonic life stage

Task page 7

2. The population of brook trout in Lake Wilmar has declined significantly since the ice-making plant was built. Explain what might have caused the change in the brook trout population.

3. If you were a ranger, explain in detail what additional experiments you would conduct to verify the information on the chart from the wildlife organization on page 4.

Task page 8

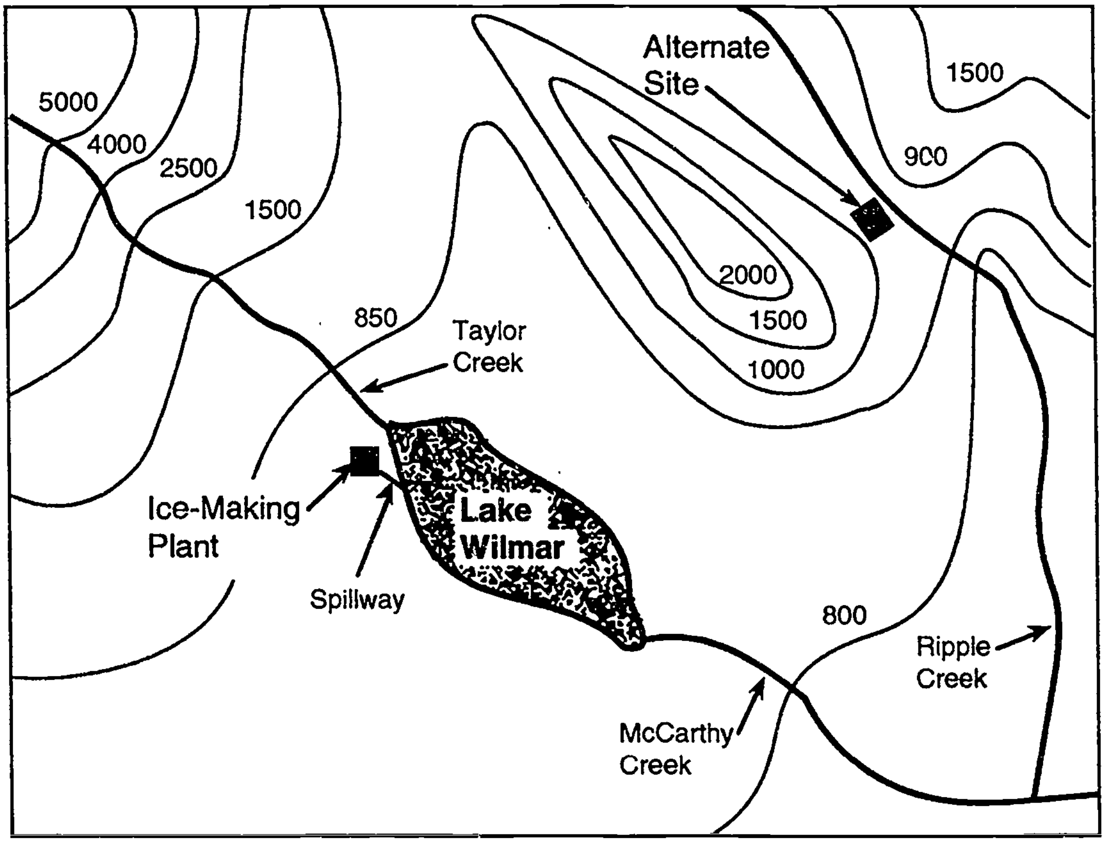
4. Explain how the information from the wildlife organization's chart and the results of your pH tests could explain the problem Captain McDermit has observed in Lake Wilmar.

Task page 9

Investigation 2 – Hot Rocks and Water

The topographical map of the Lake Wilmar area shows the ice-making plant and the alternate site on the other side of the mountain.

Map of the Lake Wilmar Area



Directions:

To investigate why the weather at the lake was cooler than an alternate site 10 miles away from the lake on the other side of the mountain, you will complete the following tasks:

- Determine the amount of heat that can be stored in a rock.
- Determine the amount of heat that can be stored in equal masses of water if they are at the same temperature.
- Compare those amounts.

The following directions can also be found on the placemat.

Part A – Water and Rock

- q Pour 100 ml of tap water into a Styrofoam cup.
- q Measure the temperature of the tap water in the cup. Record it to the right of the zero on the data chart.
- q Remove the rock from the hot water bath and place it in the Styrofoam cup containing the tap water.
- q Measure the temperature of the water in the cup every 30 seconds for 2 minutes. Record your measurements on the data chart.

Time (sec)	Temperature of Water and Rock (Part A)
0	
30	
60	
90	
120	

Part B – Water and Water

- q Take another Styrofoam cup and pour 100 ml of new tap water into it.
- q Measure the temperature of the water in the new cup. Record it to the right of the zero on the data chart.
- q Record the mass of the rock in the space provided below. (You determined this value at the beginning of the activity on page 2.)
- q Measure the same number of milliliters of hot water as you recorded for the mass of the rock. (For example, if the mass of the rock is 45 grams, then measure 45 ml of hot water from the hot water bath.) Pour the hot water into the cup of tap water. Record the mass of the water in the space provided below.
- q Measure the temperature of the water in the cup every 30 seconds for 2 minutes. Record your measurements on the data chart.

Time (sec)	Temperature of Water and Water (Part B)
0	
30	
60	
90	
120	

The density of water is
1 gram per milliliter.

1 g = 1 ml

Mass of Rock ________

Mass of Water ________

5. Use the information from your data charts to make a graph representing time and temperature for each of the trials.

Time and Temperature Graph

6. Think about the procedure you have just completed as you answer this question. One milliliter of water has a mass of 1 gram. This means that the mass of the rock and the mass of the hot water you used in this activity were equal. With this in mind, which would hold the most heat energy, 50 grams of rock at 60 °C or 50 grams of water at 60 °C? Explain your answer.

7. Lake Wilmar has fewer temperature changes during the year than the alternate inland site (see map on page 7). Explain why this happens.

Investigation 3 – Rock Erosion

Directions:

You will complete the following tasks.

- Determine the effects of tap water on limestone rock.
- Determine the effects of wastewater from the ice-making plant on limestone rock.
- Compare your results.

The following directions can also be found on the placemat.

q Place a sample of limestone rock in a clear plastic cup.

q Slowly pour enough spillway wastewater into the cup to cover the rock.

q Place another sample of limestone rock in the other clear plastic cup and cover it with fresh water.

q Observe what happens in the cups for about 3 minutes.

8. Briefly record your observations.

9. What happened when the limestone rock was covered with the spillway wastewater in the beaker? Describe a procedure you would use to verify your reasoning.

10. Would you expect the limestone rocks to react in the same way in Taylor Creek water as they did in the spillway wastewater. <u>Explain</u> why or why not.

11. After several years the surface of a marble statue in the front parking lot of the ice-making plant was worn away and covered with small holes. <u>Explain</u> what could have caused this wearing away.

Big Ideas	Grade 10 Forms 1 & 2

Task 1 – Freshwater Animal Populations

Big Idea	Exemplar
L-12: All living things interact with each other and their physical environment through distinct roles.	Aquatic organisms are affected changes by the pH of the water in which they live. Different organisms have different tolerances and therefore can not survive at pH levels where other organisms can live.
L-16: Humans affect and are affected by their environments. Human activities, both conscious and inadvertent, affect the Earth's climate, weather patterns, and the quality of natural resources such as air, water, and other living things.	Humans, by allowing chemical wastes to empty into closed bodies of water, will change the chemical nature of the aquatic environment. Some organisms which were once found in the environment will not be able to live in the chemically changed ecosystem. Due to their absence, the food chain of which these nontolerant organisms are members will also change.

Task 2 – Hot Rocks and Water

Big Idea	Exemplar
P-1: Matter has observable, physical properties that can be measured.	The amount of heat that can be stored in a substance is a physical property of that substance. The amount of heat stored by a substance can be measured.
P-10: Heat flows between regions/objects.	A heat source will transfer heat to a substance having lower heat energy.
E-6: Life is dependent on the cyclic patterns of the ocean.	The water cycle and its interconnections and implications affects living things.
E-10: Weather affects living and non-living things.	Weather effects biomes and the adaptation of living things. The weather of an area is affected by the heat stored in a major body of water.

Task 3 – Rock Erosion

Big Idea	Exemplar
E-5: The Earth's resources are limited.	Living things are affected by the amount of natural resources available to them in their environment. Nonrenewable resources of land and oceans can be co.served through careful use, recycling, and application of energy.
E-10: Weather affects living and non-living things.	Weather (wind, rain, ice, heat) affects biomes and the adaptation of living things.
L-16: Humans affect and are affected by their environments. Human activities, both conscious and inadvertent, affect the Earth's climate, weather patterns, and the quality of natural resources such as air, water, and other living things.	Humans, by allowing chemical wastes to empty into closed bodies of water, will change the chemical nature of the aquatic environment. Some organisms which were once found in the environment will not be able to live in the chemically changed ecosystem. Due to their absence, the food chain of which these nontolerant organisms are members will also change.

Component Performance | **Grade 10 - Form 1 Task 1 – Freshwater Animal Populations**

Item Number	Component Rubric
1. Record observations	Not scored.
2. Brook trout	4 = Response provides an indepth understanding, including the observed pH value of Lake Wilmar and the survival of the brook trout populations. Response includes the relationship of the elimination of the insect and minnow populations with the decline in the trout population. May state that the lower pH affects the development of the fish eggs. Uses information from table and observations to support answer. 3 = Response provides a good understanding of the affects of lower pH on the entire ecosystem and that animals upon which the brook trout feed have been eliminated from the lake. Attempts to use information from table and observations to support answer. 2 = Response demonstrates little understanding of the affects of the lower pH on the entire ecosystem. States that the acidic pH is responsible for the decline in the trout population. Does not use information from table and observations to support answer. 1 = Response demonstrates a very limited understanding of the factors that would cause the fish population to decline. Explains the population change is due to the pollution of Lake Wilmar. Does not use information from table and observations to support answer. 0 = Rewrites question. Response is off-topic. No response or inappropriate writing or drawing.

3. Additional experiments	3 = Response demonstrates a good understanding of what additional testing needs to be done and why. The experiment may include testing several variables. Relates the results to the data displayed on the wildlife chart. 2 = Response demonstrates partial understanding of what additional experimental testing needs to be done. States that only one variable needs to be tested or mentions additional tests that do not verify the information on the chart. Gives a weak explanation of how it verifies the data on the wildlife chart. 1 = Response demonstrates extremely limited understanding of what additional experimentation needs to be done. States only one variable and gives no explanation of how it verifies the wildlife chart. 0 = Rewrites question. Response is off-topic. No response or inappropriate writing or drawing.
4. Captain McDermit's problem	4 = Indepth understanding of the pH values and the changes in the animal populations in the lake. Includes an explanation of why Taylor Creek animal populations have not been affected by the spillway waste water but why populations in Lake Wilmar have been affected. 3= Adequate understanding of the affect of pH on the survival of the animal populations. Discusses the three water sources (spillway, lake, and creek water) and the pH values of each. 2 = Limited understanding of the affect of pH on the survival of the animal populations. Includes minor misconceptions. 1 = Demonstrates extremely limited understanding of the affect of pH on the survival of animal populations. Includes major misconceptions. 0 = Rewrites question. Response is off-topic. No response or inappropriate writing or drawing.

Component Performance | **Grade 10 - Form 1**
Task 2 – Hot Rocks and Water

Item Number	Component Rubric
5. Time and Temperature Graph	4 = Graphs present the data accurately. Both axes are labeled correctly. The shape of the curve correctly represents the time and temperature relationships. Both curves are identified. The entire grid is used. The X axis is time, Y axis is temperature. 3 = Graphs present the data accurately. The shape of the curve correctly represents the time and temperature relationship. The axes and the curves are labeled correctly. 2 = The data points are correctly plotted on the graphs as drawn. Axes may be reversed. The shape of the curve may not represent the temperature and time relationship. 1 = The data points are not plotted correctly. Axes are not labeled with correct measurements. The shape of the curve does not represent the temperature and time relationship. Two lines, which do not represent the time and temperature relationship, are drawn without plotting points. 0 = Rewrites question. Response is off-topic. No response or inappropriate writing or drawing.

6. Energy of water and rock	4 = Response demonstrates adequate understanding of the scientific concepts related to heat storage ability of different substances. Uses observations from their experiment as examples to support answer. 3 = Response demonstrates partial understanding of the scientific concepts related to the heat storage ability of different substances. May include a misconception. May discuss observations from previous experiment. 2 = Response demonstrates limited understanding of the scientific concepts related to the heat storage ability of different substances. Includes many misconceptions. States that both the water and the rock hold the same amount of energy because they are at the same temperature. Attempts to support this with logical reasoning, but rationale may be vague or unclear. 1 = Response demonstrates extremely limited understanding of the scientific concepts related to the heat storage ability of different substances. Major misconceptions are evident. If rationale is present, it is vague and unclear. 0 = Rewrites question. Response is off-topic. No response or inappropriate writing or drawing.
7. Temperature changes during the year	4 = Response shows indepth understanding of the effects of bodies of water on the local weather. Discusses the energy transfer of the stored energy in the lake to the surrounding land and air. 3 = Response shows adequate understanding of the effects of bodies of water on the local weather. May attempt to discuss the energy transfer of the stored energy in the lake to the surrounding land and air. May contain a misconception. 2 = Response shows little understanding of the effects of bodies of water on the local weather. Discussion includes misconceptions. May stress the change in altitude as the major cause of the changes throughout the year. 1 = Response shows extremely limited understanding of the effect of bodies of water on the local weather. Discussion if present, includes major misconceptions. 0 = Rewrites question. Response is off-topic. No response or inappropriate writing or drawing.

Component Performance	Grade 10 - Form 1 Task 3 – Rock Erosion

Item Number	Component Rubric
8. Record your observations	Not scored.
9. Limestone in spillway water	4 = Indepth description of what happened when the limestone is put into the spillway water. Discusses in detail a method to experimentally verify that the spillway water is responsible for the rock erosion. 3 = Adequate description of what occurred when the limestone is put in the spillway water. Experimental design lacks detail. A misconception (identity of limestone) may be present. 2 = Limited description of what happened to the limestone. Flaws in experimental design. Misconceptions are present. 1 = Extremely limited description of what happened to the limestone. Major flaws in the experimental design. Major misconceptions present. 0 = Rewrites question. Response is off-topic. No response or inappropriate writing or drawing.
10. Rocks in Taylor Creek vs Lake Wilmar	3 = Adequate response. Answer is based on the different pH values recorded in the Freshwater Populations Task. Response includes discussion of different reaction rates in higher concentrations of acids. 2 = Partially adequate response. Answer includes limited discussion of reaction rates in higher concentration of acids. May have a minor misconception (not knowing identity of pollutant in the spillway water.) 1 = Inadequate response. Answer is very brief and gives little explanation of the reaction rates in different concentrations. Mainly 'filler' with one or more major misconceptions. 0 = Rewrites question. Response is off-topic. No response or inappropriate writing or drawing.

11. Marble statue	4 = Response demonstrates indepth understanding of the concept of acid rain or some form of air pollution that could be responsible for the chemical weathering. Recognizes that the spillway waste water is not to blame for the statue corroding, but that the ice making plant may be giving off other air pollutants that would affect the marble statue.
	3 = Response demonstrates adequate understanding of the concept of acid rain or air pollutants, and the effects that they would have on a marble statue in the area. A minor misconception may be cited in the discussion.
	2 = Response demonstrates partially adequate understanding of the concept of acid rain or air pollutants and the effects that they would have on a marble statue in the area. Several misconceptions are found in the discussion.
	1 = Response demonstrates an extremely limited understanding of the concept of acid rain or air pollutants and the effects that they would have on the marble statue. If discussion is present, it may attempt to relate the erosion of the statue to the spillway water. Major misconceptions.
	0 = Rewrites question. Response is off-topic. No response or inappropriate writing or drawing.

Component Rubric
Performance Task

Grade 10
Investigation 1: Decline in Freshwater Animal Populations

Rater: ______________________ Form: ______________________

Date: ______________________ Time: ______________________
a.m. p.m.

Directions: Write in (1) score for each item.

Student ID Number	Item Numbers 1	2	3	4
1.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
2.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
3.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
4.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
5.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
6.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
7.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
8.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
9.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
10.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
11.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
12.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
13.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
14.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
15.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0

Science Research Pilot, Spring 1993

Component Rubric Performance Task

Grade 10 Investigation 2: Hot Rocks and Water

Rater: ______________________ Form: ______________________

Date: ______________________ Time: ______________________
a.m. p.m.

Directions: Write in (1) score for each item.

Student ID Number	Item Numbers		
	5	6	7
1.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
2.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
3.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
4.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
5.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
6.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
7.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
8.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
9.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
10.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
11.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
12.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
13.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
14.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
15.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0

Science Research Pilot, Spring 1993

Component Rubric
Performance Task

Grade 10
Investigation 3: Rock Erosion

Rater: ______________________ Form: ______________________

Date: ______________________ Time: ____________ ____________
a.m. p.m.

Directions: Write in (1) score for each item.

Student ID Number	Item Numbers 8	9	10	11
1.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
2.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
3.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
4.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
5.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
6.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
7.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
8.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
9.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
10.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
11.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
12.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
13.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
14.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0
15.	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0	4 3 2 1 0

Science Research Pilot, Spring 1993

Appendix

Student and Teacher Surveys

This appendix includes surveys given to eighth-grade students who participated in the project in 1994 and to teachers whose classes participated in 1993 and 1994. Both student and teacher surveys attempted to ascertain the extent to which the skills and knowledge tested in the assessments had been taught in class. The student survey also sought information on attitudes toward the hands-on assessments.

Name:______________________ Date of Birth: ______ /_____ /______
Last First Month Day Year

For each question, please **circle** the number that matches your answer.

1. **Before this week, have you ever done the following science activities?** (Circle one or more answers for each activity.)

	No	Yes, in 8th grade science	Yes, in another class
a. Used litmus paper to see if a solution was an acid or a base	1	2	3
b. Used any method to measure the pH number of a solution	1	2	3
c. Measured the lifting power of levers	1	2	3
d. Classified different things (such as plants, animals, or materials) into groups.	1	2	3

2. Before this week, how many times have you done the following activities in your <u>8th grade science class</u>? (Circle one answer for each activity.)

	Never	1-2 times	3-4 times	5-6 times	7 or more times
a. Did experiments where I was told all the steps to follow	1	2	3	4	5
b. Did experiments where I had to figure out several steps without the teacher's help	1	2	3	4	5
c. Worked with one or more lab partners to do experiments	1	2	3	4	5
d. Did experiments by myself	1	2	3	4	5
e. Did experiments where I used scientific equipment, such as magnifying glass, graduated cylinder, or balance	1	2	3	4	5

3. Did you learn anything in science class this year that helped you solve the following problems? (Circle one answer for each problem.)

	No	Not sure	Yes
a. Find which medicine would cure the alien	1	2	3
b. Find the stronger of two acids	1	2	3
c. Find whether length or pivot point affected the lifting power of levers	1	2	3
d. Classify materials	1	2	3

4. **How many of the questions do you think you answered correctly on the following activities?** (Circle one answer for each activity.)

	None	A few	One-half	Most	All
a. Find which medicine would cure the alien	1	2	3	4	5
b. Find the stronger of two acids	1	2	3	4	5
c. Find whether length or pivot point affected the lifting power of levers	1	2	3	4	5
d. Classify materials	1	2	3	4	5

5. **How <u>interesting</u> was each of the following activities?** (Circle one answer for each activity.)

	Very boring	Boring	Neutral	Inter-esting	Very inter-esting
a. Find which medicine would cure the alien	1	2	3	4	5
b. Find the stronger of two acids	1	2	3	4	5
c. Find whether length or pivot point affected the lifting power of levers	1	2	3	4	5
d. Classify materials	1	2	3	4	5

RAND Study of Performance Assessment Spring 1993

Teacher Questionnaire

Thank you for agreeing to participate in this project. We ask you to take a few minutes to respond to these questions about your class.

Your name: ____________________ School: ______________________
Class: ______________________

1) On the average, how many hours per week do you spend on science with this class? ____ hours

2) How often do you incorporate hands-on activities into your science teaching? (Circle one)

Daily or almost daily 1
Several times a month 2
Once or twice a month....................... 3
A few times per term 4
Rarely or never 5

3) What proportion of the hands-on science activities your students engage in are of the following types:

Following clear directions to manipulate materials or equipment

____

Open-ended explorations without specific directions?

____

4) Have you taught these students about <u>force and motion</u> this year? Yes No If yes, how many class periods did you devote to this topic? ________________ How many of these periods included hands-on activities for the students?

5) Have you taught these students about <u>classification</u> this year? Yes No If yes, how many class periods did you devote to this topic? ________________ How many of these periods included hands-on activities for the students? _______

6) Have you taught these students about <u>pendulums</u> this year? Yes No If yes, how many class periods did you devote to this topic? ________________ How many of these periods included hands-on activities for the students? _______

7) Have you taught these students about <u>levers</u> this year? Yes No If yes, how many class periods did you devote to this topic? ________________ How many of these periods included hands-on activities for the students? _______

RAND Study of Performance Assessment Spring 1994

Teacher Questionnaire

Name:______________________________ Date: ______________ Period: ______
Last First

For each question, please **circle** the number that matches your answer.

1. **Have you taught as a new subject or reviewed the following topics with this class during this school year?** (Circle one response for each topic.)

	Yes, taught as new	Yes, reviewed only	Not yet, but I will	No
a. Chemical properties of acids and bases	1	2	3	4
b. Neutralizing an acid with a base	1	2	3	4
c. Using litmus paper to test acidity	1	2	3	4
d. Measuring the pH number of a solution	1	2	3	4
e. Force and work	1	2	3	4
f. Friction	1	2	3	4
g. Levers and pulleys	1	2	3	4
h. Sorting or classifying based on similar properties	1	2	3	4
i. Two-way classification (using two different properties at the same time)	1	2	3	4

2. **How frequently do students in this class use the materials and equipment below during class time?** (Circle one response for each type of equipment.)

	Never	1 or 2 times a year	1 or 2 times a month	1 or 2 times a week	Almost every day
a. Calculator	1	2	3	4	5
b. Computer	1	2	3	4	5
c. Magnifying glass, microscope	1	2	3	4	5
d. Telescope, planetary models	1	2	3	4	5
e. Weights, scales, balances	1	2	3	4	5
f. Batteries, wires, bulbs	1	2	3	4	5
g. Flasks, test tubes, chemicals	1	2	3	4	5
h. Rocks, minerals	1	2	3	4	5
i. Dissecting tools	1	2	3	4	5
j. ANY equipment or materials	1	2	3	4	5

3. How many periods have you already spent on each topic below with this class? If you focused on the topic for 10-15 minutes on a day, count that as a period. Do <u>not</u> include time you will spend in the future. (Circle one response for each topic.)

	None	1-2 periods	3-5 periods	6-10 periods	More than 10 periods
a. Chemical properties of acids and bases	1	2	3	4	5
b. Neutralizing an acid with a base	1	2	3	4	5
c. Using litmus paper test acidity	1	2	3	4	5
d. Measuring the pH number of a solution	1	2	3	4	5
e. Force and work	1	2	3	4	5
f. Friction	1	2	3	4	5
g. Levers and pulleys	1	2	3	4	5
h. Sorting or classifying based on similar properties	1	2	3	4	5
i. Two-way classification (using two different properties at the same time)	1	2	3	4	5

4. About what percent of class time is spent in a TYPICAL WEEK doing each of the following with this class. (Circle one response for each activity. The total need NOT sum to 100%.)

	None	<10%	10-24%	25-49%	50-74%	75%+
a. Providing instruction to the class as a whole	1	2	3	4	5	6
b. Providing instruction to small groups of students	1	2	3	4	5	6
c. Providing instruction to individual students	1	2	3	4	5	6

d. Demonstrating lab procedures or experiments to students	1	2	3	4	5	6
e. Supervising labs in which students do experiments	1	2	3	4	5	6
f. Administering tests or quizzes	1	2	3	4	5	6
g. Supervising field trips	1	2	3	4	5	6
h. Performing administrative tasks (e.g., taking attendance)	1	3	3	4	5	6
i. Doing other school activities not related to the subject	1	3	3	4	5	6

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